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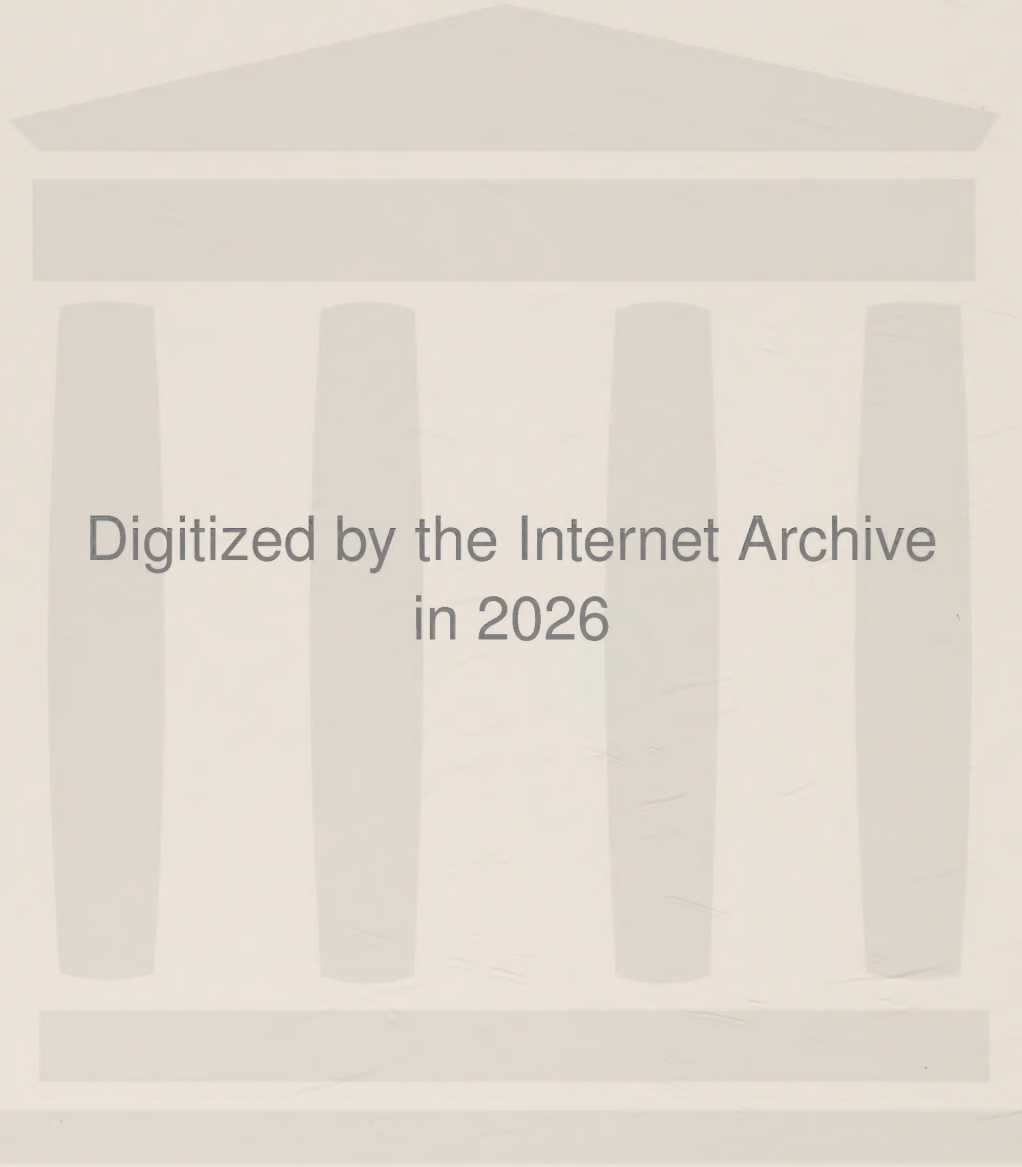
LATE WEICHSELIAN STRATIGRAPHY OF BLEKINGE, SE SWEDEN,
AND WATER LEVEL CHANGES IN THE BALTIC ICE LAKE

av

Svante Björck
Fil.kand., Mlm

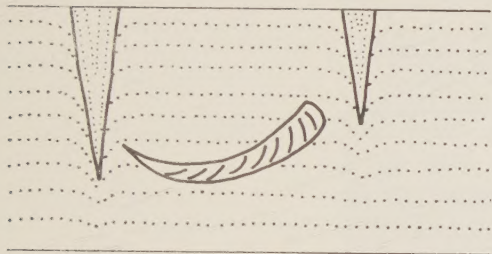
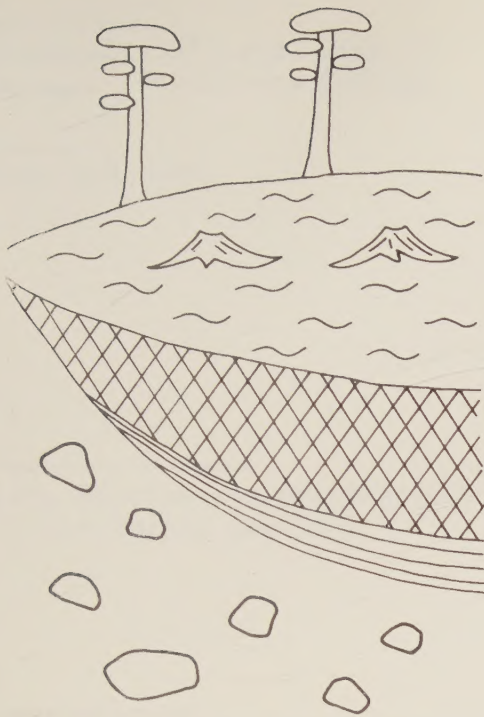
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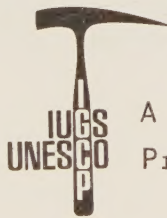
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THESIS 7

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LATE WEICHSELIAN STRATIGRAPHY OF BLEKINGE,
SE SWEDEN, AND WATER LEVEL CHANGES IN THE
BALTIC ICE LAKE



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Late Weichselian stratigraphy of Blekinge, SE Sweden, and water level changes in the Baltic Ice Lake.

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The investigations were carried out in Blekinge, south-eastern Sweden. Sixteen basins were analysed in respect of Late Weichselian pollen- and chronostratigraphy. The isolation of the basins from the Baltic Ice Lake (BIL) has been determined by nine different isolation indicators and dated by the radiocarbon dated regional pollen assemblage zones. This has produced a shore line displacement curve for the BIL, characterized by at least two transgressions and two tappings. The lithostratigraphy of Blekinge is described and related to the deglaciation pattern, Late Weichselian sedimentation, chronology and shore line displacement. The deglaciation was characterized by calving as well as by downwasting of ice. The local varve chronology is linked with the pollen- and chronostratigraphy. Geological events recorded from Blekinge are believed to show a complex picture of the Late Weichselian development of the Baltic basin as well as explaining parts of the deglaciation of southern Scandinavia.

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CONTENTS

1.	INTRODUCTION	1
2.	THE INVESTIGATION AREA	3
	1. Situation, topography and pre-Quaternary geology	3
	2. Quaternary deposits	8
	3. Historical outline of previous investigations	9
3.	STRATIGRAPHY	19
	1. Biostratigraphic subdivision	19
	2. Chronostratigraphic subdivision and terminology	19
	3. Lithostratigraphic subdivision and terminology	19
4.	FIELD WORKS AND METHODS	21
	1. Coring and sampling in lakes and peatbogs	21
	2. Threshold investigations of the analysed basins	22
	3. Investigations of the lithostratigraphy of river valleys in Blekinge	22
	4. Studies and measurements of varved clay	23
	5. Studies of aerial photographs	24
	6. Determination of loss on ignition	24
	7. Determination of the magnetic susceptibility of lake sediments	24
	8. Mineralogical analysis of clay	25
	9. Radiocarbon analyses	26
	10. Pollen analyses	27
	11. Diatom analyses	33
	12. Numerical methods	34
5.	DESCRIPTION AND STRATIGRAPHY OF THE INVESTIGATED BASINS ...	37
	1. Vitavattsgyl	37
	2. Sannen	41
	3. Logylet	45
	4. Årsjön	54
	5. Kroksjön	58
	6. Dönhultagyl	66
	7. Sjalbredan	70
	8. Lilla sjön	71
	9. Galtsjön	75
	10a. Halsjön I	80
	10b. Halsjön II	86
	11. F.d. Paddegölen	92
	12. Norrsjön	98

13.	F.d. Togölen	102
14.	Getsjön	107
15.	Harstorpssjön	110
16.	Bredsjön	113
6.	ABSOLUTE CHRONOLOGY AND REGIONAL POLLEN STRATIGRAPHY	118
	1. The radiocarbon dates	118
	2. The regional pollen assemblage zones and their relation to absolute chronology	120
7.	WATER LEVEL CHANGES IN THE BALTIC ICE LAKE	133
	1. Isolation indicators	133
	2. Dating of the isolation levels and interpretation of water level changes in the investigated basins	137
	3. Late Weichselian shore line displacement in Blekinge with comparisons to investigations in other parts of the Baltic	144
8.	DESCRIPTION AND STRATIGRAPHY OF THE INVESTIGATED RIVER VALLEYS	153
	1. The Mieå river valley	153
	2. The Bräkneå river valley	167
	3. The Ronnebyå river valley	184
	4. The Åbyå river valley	193
	5. Investigations of the morphology of nine esker systems in Blekinge	202
9.	THE REGIONAL LITHOSTRATIGRAPHY RELATED TO ABSOLUTE CHRONOLOGY AND SHORE LINE DISPLACEMENT	207
10.	THE RELATION BETWEEN THE REGIONAL BIO- AND LITHO- STRATIGRAPHY BASED ON THE CHRONOLOGY	212
11.	THE DEGLACIATION OF BLEKINGE	214
	1. Dating of the deglaciation	214
	2. The deglaciation pattern	216
12.	LATE WEICHSELIAN GEOLOGICAL EVENTS WITHIN AND AROUND THE BALTIC BASIN - A REGIONAL SYNTHESIS	225
	ACKNOWLEDGEMENTS	236
	REFERENCES	240

1. INTRODUCTION

The province of Blekinge, situated in the south-eastern corner of Sweden, has been subjected to different types of Quaternary investigations during the last decade. Berglund's monograph from 1966 mainly dealt with the vegetational, climatic and human development of the province, but he also constructed a shore line displacement curve for the 'Late-Glacial time' in Blekinge. Ringberg (1971) described and dated the deglaciation of eastern Blekinge and fixed the highest shore line in the area. The deglaciation was dated by Nilsson's (1968) Swedish varve chronology, while deposits and events relating to the level of the Baltic Ice Lake were frequently dated by Berglund's shore line displacement curve. Investigations in the Mörrumså river valley by Lagerlund (1974) showed that it is possible to distinguish between delta sediments and glacio-fluvial deposits. He also showed that the area between 55 and 30 m a.s.l. in the Mörrumså river valley is characterized by delta surfaces at different altitudes.

It is mainly in the light of these three works that my own investigation started in the summer of 1974. The main task was to construct a detailed shore line displacement curve of the Baltic Ice Lake in Blekinge and to relate this curve to the deglaciation as well as to the fluvial and lacustrine environment characterizing the investigation area after deglaciation.

It was planned to determine the shore line displacement curve by dating the isolation of several basins situated at different altitudes below the highest shore line. Datings would be determined by radiocarbon analyses as well as by pollen analysis. In addition to obtaining a shore line displacement curve, these analyses would also result in a pollenstratigraphy which could be related to the Late Weichselian chronostratigraphy (Mangerud et al. 1974).

In order to attempt an interpretation of the deglaciation of the investigation area and the presence of different types of deposits characterizing the areas situated below the highest shore line, it was also necessary to undertake lithostratigraphical investigations. These investigations have mostly been confined to the river valleys as the most complete lithostratigraphy is found in such areas. The majority of sites investigated consist of gravel pits or bore-holes.

These stratigraphical investigations have been combined with morphological studies of the area in order to relate the lithostratigraphy to different types of morphology, and, finally, to the depositional environment.

The synthesis of this combined investigation is a relationship between the shore line displacement and the lithostratigraphy based on an absolute chronology. This relationship has been further confirmed as it has been possible to relate the local varve chronology with the Late Weichselian chronostratigraphy (Mangerud et al. 1974).

It has proved possible to correlate the Late Weichselian geological development in Blekinge with parts of the Late Weichselian development in the Baltic basin, and also with the deglaciation of certain other parts of Southern Sweden.



Fig. 1. Map showing the province of Blekinge with the investigation area.

2. THE INVESTIGATION AREA

2.1. Situation, topography and pre-Quaternary geology

The investigation area comprises the greater part of the province of Blekinge, SE Sweden (Figs. 1 and 2). The area is bounded by the Mörrumså river valley to the west and by the Åbyå river valley to the east. To the north the area is roughly delimited by the 80 m contour line and to the south by the Baltic.

The area as a whole is a lowland. From south to north it comprises the coastal plain with its archipelago, the valley landscape with

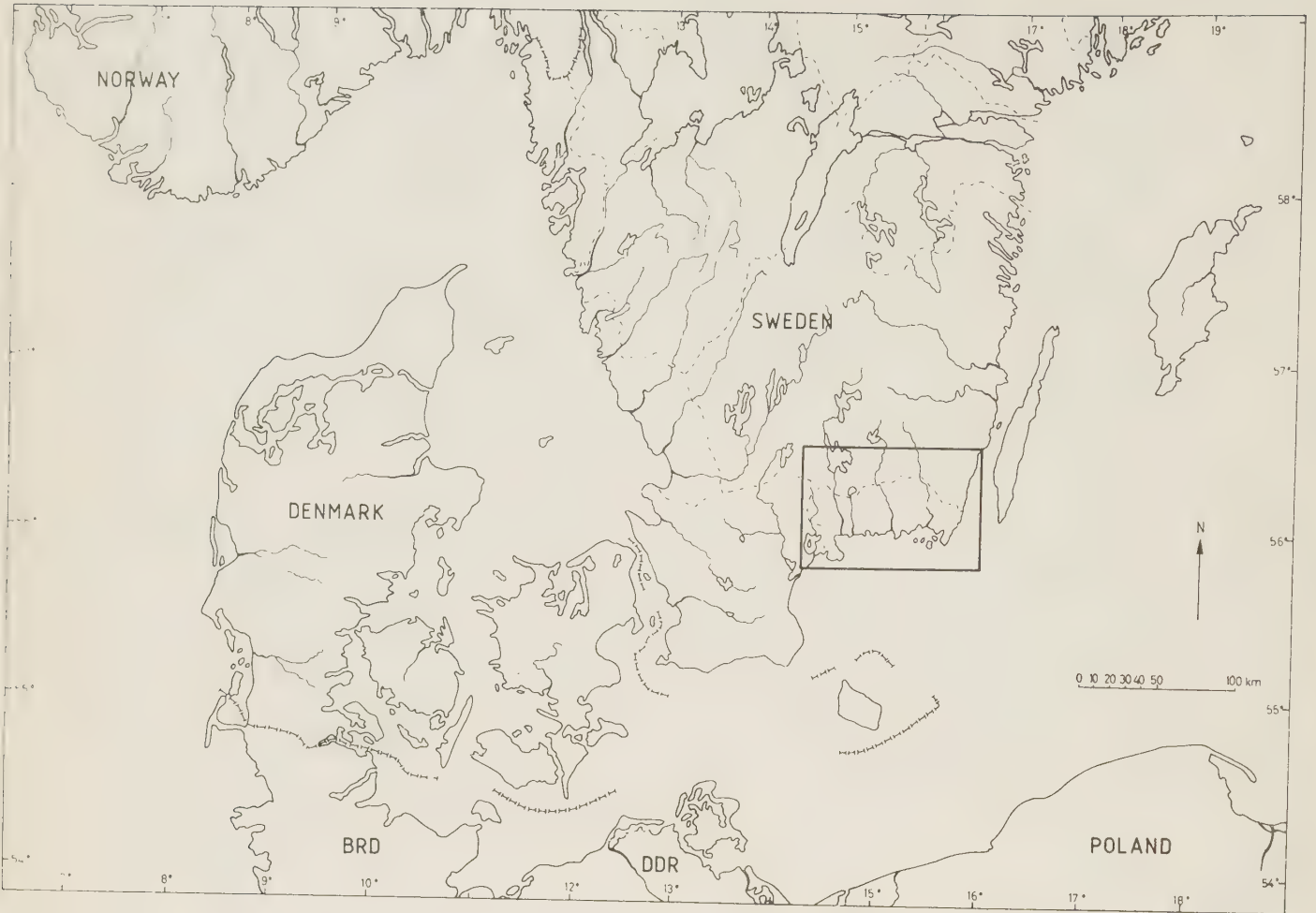


Fig. 2. The area shown in Fig. 1 related to southern Scandinavia.

usually NW-SSE directed river valleys, the northern area of uneven topography and finally the north Blekinge plain. This division, which was originally made by Björnsson (1946) and later slightly modified by Berglund (1966), is shown in Fig. 4.

Blekinge belongs to the southeasternmost part of the Baltic shield or Fennoscandia (Behrens, 1960), which is a Precambrian region, and forms the southeastern marginal area of the South Swedish Upland. The bed-rock map (Fig. 3) is a compilation made by Wiklander (1973) after old and more recent geological map material. It is clear that gneiss and granite dominate the investigation area completely. What is not clear from this map is the fact that the western part of Blekinge is relatively rich in diabase dikes, usually orientated in a NNE-SSW direction (Moberg, 1896).



Fig. 3. Bed-rock map of Blekinge, compiled by Wiklander 1972. After Wiklander 1973.

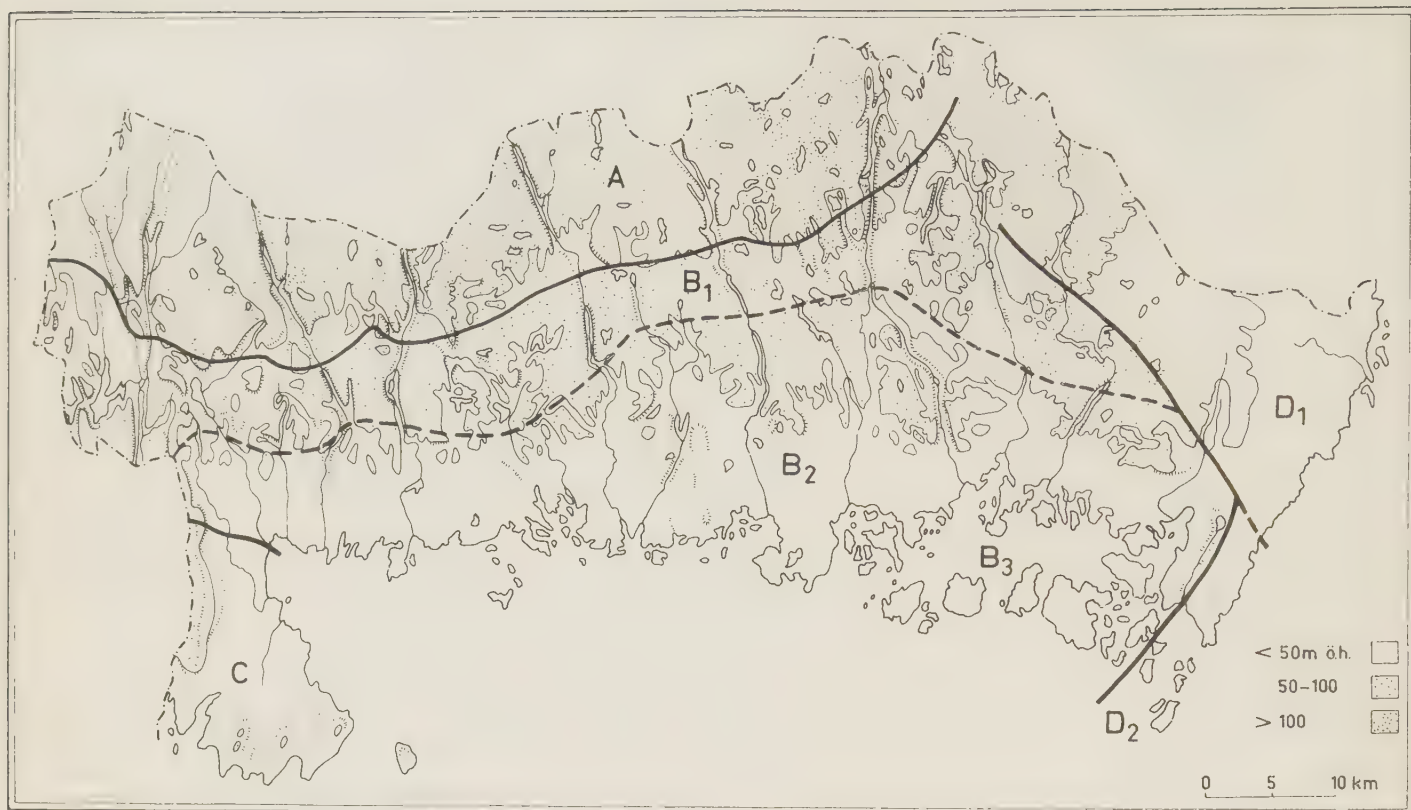


Fig. 4. Blekinge from a topographical point of view, mainly according to Björnsson (1946). A) THE NORTH BLEKINGE PLAIN, B) THE VALLEY LANDSCAPE, subdivided into a northern broken area (B₁) and a southern rather plain area (B₂) to which the archipelago (B₃) is connected, C) THE LISTER PENINSULA, D) THE EAST BLEKINGE PLAIN. The boundary for the last-mentioned area has been slightly changed by Berglund (1966). The mainland area (D₁) also comprises the eastern part of the Torhamn Peninsula to which the archipelago east of Hästholmen (D₂) is related.

According to Larsson (1954) the bed-rock studied by him in the western part of Blekinge has been deformed. This deformation is at least partly due to folding. Post-crystalline deformation is a possible explanation (Larsson, 1967) of the abundance of narrow and deep valleys in Blekinge. The original joints or fractures were later deepened and widened by glacial and fluvial erosion. The presence of these valleys (Fig. 5) with the many lakes has given Blekinge its uneven topography. The bed-rock topography in Blekinge is often stepped. At the lowest step the valleys usually widen and lead to the flat coastal plain (Fig. 6).



Fig. 5. The Bräkneå river valley between Örseryd and Sävsjömåla, 15 km from the coast.



Fig. 6. The pronounced fissure valley at Dallhejaberg, between Åryd and Bräkne-Hoby. The difference in altitude is 45 m.

2.2. Quaternary deposits

The only complete mapping of the Quaternary deposits in Blekinge was carried out by Blomberg (1900). His map gives a rough idea of how different deposits in Blekinge are distributed. In combination with many small but more detailed investigations a more complete picture is obtained.

The archipelago is characterized by bare bed-rock, sometimes covered with a thin, relatively coarse till. Areas below 10 m a.s.l. at the coast have been influenced by the Holocene transgressions, which means that organic deposits such as peat and gyttja are common. Holocene clays are found at the lowest altitudes. Apart from the above mentioned deposits, sandy silt and sometimes varved clay dominate the coastal plain. Bed-rock is rare, but when it appears it is usually bare. Between 5 and 10 km from the coast the river valleys begin to characterize the landscape. The areas between these southern parts of the valleys are dominated by thin till deposits. Now and then bare bed-rock as well as small peat-bogs appear. The southern parts of the valleys are wide and dominated by silty and sandy deposits. Typical for these lower parts of the valleys is the occurrence of usually rounded ridges in the middle of the valleys, consisting of pebbles, gravel and sand. Further northwards the valleys get narrower and in some of the larger river valleys extensive plains occur, situated between 50 and 60 m a.s.l. These consist mainly of sand and silt. North of these altitudes the valleys, with some exceptions, are very narrow. The dominant Quaternary deposits in these parts are usually very coarse. Either they are shaped as well-marked rather long as well as very short ridges, or as delimited terraces or plains. The large areas between the valleys are rich in lakes as well as in peat-bogs, and the highest situated areas are characterized by a hummocky terrain, consisting mainly of till, which now and then is relatively thick. One of the main characteristics of this till is the richness of boulders. In areas situated higher than 70 m a.s.l. this type of terrain dominates completely. The Quaternary deposits can be summarized as follows.

- 1/ Till is the dominant Quaternary deposit in Blekinge.
- 2/ Coarse, sorted deposits are most common in the river valleys at altitudes of more than 55 m, but is also relatively common

in the easternmost parts of Blekinge at lower altitudes.

- 3/ Below 55 m a.s.l. sand and silt are most common.
- 4/ The southernmost part of the coastal plain is dominated by fine-grained sediments.
- 5/ Organic deposits, such as peat and gyttja, usually appear at altitudes lower than 10 m or higher than 30 m.

2.3. Historical outline of previous Quaternary investigations

2.3.1. Glacial striae and till

Studies of glacial striae started early in the area, as they were thought to give detailed information about the different ice streams covering the area. Blomberg (1900) thought that the striae in the western and greater part of Blekinge had a direction from the NNE to the SSW. He also discussed the presence of striae showing that a Baltic ice stream influenced the southeastern part of Blekinge from the SE. Holmström (1904) thought that there were traces of four ice streams in Blekinge, which is supported not only by his own observations, but also by observations made by Lundbohm (1888) and Blomberg (1900). These ice streams are as follows: 1/ the Old Baltic ice stream, which moved from east to west, 2/ an ice stream from the NNW, which covered the whole province, 3/ an ice stream from north to south, and according to Holmström this ice stream, which was influenced by a Baltic ice stream in eastern Blekinge, was the youngest ice stream on the mainland of Blekinge, d/ an ice stream from east to west, which Holmström related to the Low Baltic ice stream. The last ice stream only influenced the southeastern archipelago of Blekinge. Wennberg (1949) and Mörner (1969) supported the idea that there are traces of a Baltic ice stream in the area. Ringberg (1971) investigated the area between Ronneby and the east-coast. He found that the youngest glacial striae in eastern Blekinge show an ice movement from $N5^{\circ} - 10^{\circ}W$. Ringberg thought that this ice movement, although it seems to have been relatively weak, was not particularly influenced by the local topography. An older system of striae shows ice movement from $N20^{\circ} - 40^{\circ}E$. This striae direction is particularly common east of Karlskrona. East of Karlskrona an even older striae system shows ice movements from $N30^{\circ} - 60^{\circ}V$, which corresponds to a striae system oriented $N15^{\circ} - 25^{\circ}W$ observed over all Ringberg's investigation area. Ringberg was of the opinion that the Baltic

ice did not influence the last ice movement in eastern Blekinge. He also stated that, as there seems to be no deviation caused by topography during the youngest ice movement, the ice within big parts of the area simultaneously lost contact with the active ice and turned into dead-ice. This is further supported by the fact that Ringberg has not found terminal moraines within the area, which, however, Munthe (1940) and Bergdahl (1947) claimed they had done. Munthe's site lies northeast of Backaryd, in the northern middle part of Blekinge, while Bergdahl found terminal moraines in northeastern Blekinge. The drumlins southeast of Ronneby (G. Lundqvist 1946; Berglund 1966) are the only signs of an active ice previous to the last ice movement in the eastern half of Blekinge (Ringberg 1971).

According to Blomberg (1900) till is the most common Quaternary deposit in Blekinge. Below the highest shore line the till is thin and usually follows the topography of the underlying bed-rock, while it can be much thicker (up to 10 m) above the highest shore line and have independent form. These observations by Blomberg (1900) are supported by Ringberg (1971). G. Lundqvist (1946) mentioned abraded till reminiscent of a glacio-fluvial sediment northeast of Jämjö in eastern Blekinge. Ringberg (1971) also pointed to the importance of wave-washing of tills in exposed areas. The grain-size and bed-rock content of the tills have been carefully investigated by Ringberg (1971). Although earlier investigations have been made concerning these components of the till (Lundbohm 1888; Blomberg 1900; Lundqvist 1946; Bergdahl 1965), I shall only refer to the investigation carried out by Ringberg. He showed that the till is usually sandy or slightly silty and often containing between 5 and 15 % clay. The lime content of the till is about 1 % and it is not related to the content of clay particles. Archean bed-rock, gneiss and granite, dominates the rock material of the fine-gravel fraction. Red and grey Småland porphyries seem to be evenly distributed, reaching values of 11 %. The values of sedimentary bed-rocks do not, with one exception, exceed 0.5 %.

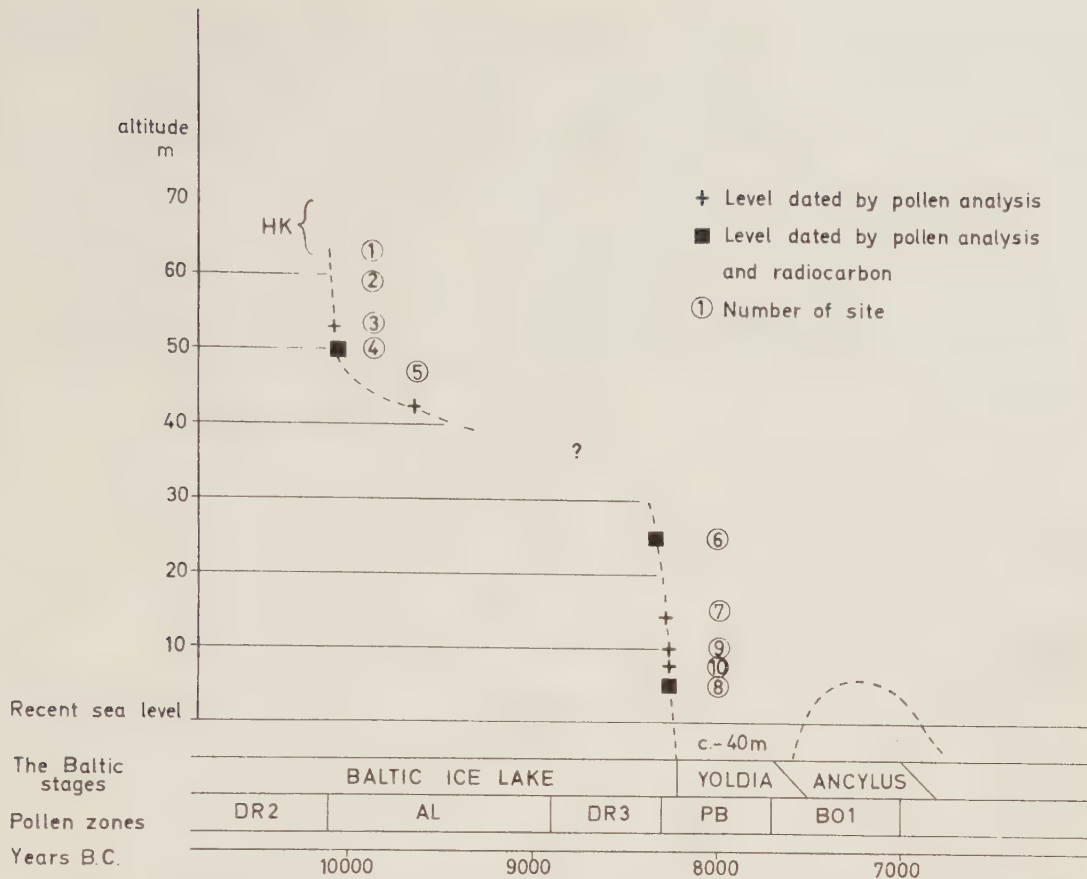


Fig. 7. Diagram illustrating the shoreline displacement during the Late-Glacial time in eastern Blekinge, according to Berglund (1966).

2.3.2. The highest shore line and the shore line displacement

Many investigations have been carried out to determine the highest shore line in Blekinge. The estimated altitude varies between 45 m a.s.l. (De Geer 1882-83) and 88 m a.s.l. (Munthe 1940). However, most of the values lie between 55 and 70 m a.s.l. (Blomberg 1900; De Geer 1910; Andersson 1927; Bergdahl 1953; Hellberg 1964 and 1971; Ringberg 1971; Dahlberg 1976; Malmberg 1976; Nilsson 1976; Svensson 1976; Edvardsen 1979). All of the values between 55 and 60 m a.s.l., which are quite numerous, originate from the western part of Blekinge, with the majority from the hill ridge Ryssberget, at the border between the two provinces of Skåne and Blekinge. Ringberg (1971) determined the highest shore line in the eastern half of Blekinge at an altitude between 63.6 and 67.5 m a.s.l., by examining the erosion boundary between non-washed and washed till at 25 localities. Ringberg thought that the highest shore line is metachronous, but says that it can be designated as approximately synchronous.

Nilsson (1953 and 1968) thought that the extremely high values of the highest shore line, determined by himself and Munthe (1940), was followed by a tapping of the Baltic Ice Lake and slightly later a transgression up to 56 m a.s.l. at Ronneby. This was then followed by a regression until the final tapping was preceded by two tappings. However, Caldenius (1944) and Mörner (1970) were of the opinion that only one tapping (at Billingen) took place during the Baltic Ice Lake stage. Berglund (1966) presented a shore line displacement curve for Blekinge (Fig. 7). It was the first really careful investigation in Blekinge concerning these problems. It was made in an attempt to date the isolation of several basins, situated at different altitudes, from the Baltic Ice Lake. Dating was made either by radiocarbon analyses or by pollen analyses. He came to the conclusion that the deglaciation was followed by a rapid regression after which followed a period of slow regression. The development of the Baltic Ice Lake was concluded by drainage from 20-25 m a.s.l. down to about 40 metres below sea level. This was related to the tapping at Billingen and dated to the very beginning of the Preboreal pollen zone. It should however be noted that Berglund has indicated a question mark for the period corresponding to the shore line displacement between 40 and 30 m a.s.l. The reason for this was the lack of investigated sites between these altitudes. This curve was later used by Mörner (1970) to indicate the presence of just one tapping of the Baltic Ice Lake. According to Ringberg (1971) the shore line displacement just after the deglaciation was 7m/100 years. This value was calculated by relating the varve chronology to the erosion of the lower plains of the Bredåkra and Rödeby deltas. Björck and Möller (1976) related the late glacial sedimentation in eastern Blekinge to the shore line displacement, and Björck and Möller (1977) published a shore line displacement curve for Blekinge, which was extensively revised by Björck (1978), showing a quite new picture of the development of the Baltic Ice Lake in Blekinge. That curve will be slightly changed in this work. A more detailed discussion concerning the development of the Baltic Ice Lake will take place in Chapter 7 and onwards, where comparisons with investigations carried out in Finland and in the Soviet Union will also be made.

2.3.3. Glacio-fluvial deposits

This sector will deal with deposits, which up to 1971 were interpreted as being of glacio-fluvial origin. These deposits can be roughly divided into two kind of formations, namely eskers and glacio-fluvial deltas. Blomberg (1900) mapped the whole province of Blekinge. Although he did not interpret all deposits found, he evidently regarded those which were later interpreted as glacio-fluvial as being at least of glacio-fluvial origin. Andersson (1927) carried out a detailed investigation of the so-called Bredåkra delta, north of Ronneby, and interpreted it as a glacio-fluvial delta deposited at the highest shore line. This delta has been correlated with different ice-marginal zones by different authors (De Geer 1912; G. Lundqvist 1961; Nilsson 1968; Mörner 1969, 1970 and 1975a; Berglund 1971a). Ringberg (1971) paid special attention to the deglaciation of eastern Blekinge, and made a thorough investigation of appropriate glacio-fluvial deposits. In contrast to Blomberg (1900) and Wennberg (1949), Ringberg maintained that the directions of the eskers are independent of the directions of the glacial striae. Instead they seem to be influenced by the local topography. According to Ringberg (1971) the two deltas within his investigation area, the Bredåkra delta and the Rödeby delta, are formed at and slightly below the highest shore line, as they are situated between 67 and 55 m a.s.l. The lower delta plains are interpreted as being incompletely built up plains. Ringberg thinks that the esker situated in the delta is a feeding esker, which provided the delta with most of its material. As he interprets the uppermost sandy and gravelly stratum of the lower plains in the Bredåkra delta as being sediments abraded by wave-washing during the regression, he relates the presence of the so-called 'diffuse' varves to the abrasion of these plains. This diffuse varve type is briefly described as follows (Ringberg 1971, p. 164): 'These varves have a diffuse appearance with winter layers divided into grey and red-brown laminae of clay which sometimes also contain very thin laminae of silt. It is clear from the diagram that the described varves during a part or whole of the corresponding time period are thicker than those which were formed just before this period.' One reason for relating the erosion of the delta surfaces to this varve type is that these diffuse varves are most typical at localities south of the two deltas. However, Ringberg (1974) pointed out the possibility of

the Bredåkra delta as being deposited at the water level of the Baltic Ice Lake or during a transgression. He regarded the latter possibility as less probable. Lagerlund (1974) showed the presence of varved clay beneath a complete delta sequence in the Mörrumså river valley. This varved clay is itself underlain by an esker. The top surface of the delta is situated at about 55 m a.s.l. This stratigraphy made it possible to separate the glacio-fluvial deposits, represented by the esker, from the delta sequence. With the purpose of investigating how regional this stratigraphy is, Lagerlund's work has been followed by my own investigations and by studies carried out during student projects. The results of these investigations are described in this work and summarized by Lagerlund and Björck (1979). We have divided the lithostratigraphy of Blekinge into stratigraphical units, which show that the deltas situated between 50 and 60 m a.s.l. should be regarded as extra marginal deltas. Mörner (1975a) thought that the Bredåkra delta was formed about 100 years after the deglaciation of the area, due to a climatic deterioration.

2.3.4. Varved clay and chronology

The varved clay in Blekinge is not usually found above 40 m a.s.l. (Blomberg 1900; Ringberg 1971), and the thickness is generally between 1 and 3 m. However, Ringberg once found at least 8 m. The boundaries between the summer and the winter layers are usually sharp. While the summer layers consist of light-grey silt, the winter layers consist of heavy clay, with colours varying between red-brown and grey-blue (Ringberg 1971). A special varve type, the diffuse varves, was described in the previous section.

Ringberg's work from 1971 is based on 40 varved clay localities, 22 of which were taken from G. De Geer's unpublished reports from Ringberg's investigation area. This resulted in a chronology, which Ringberg linked up with the revised Swedish geochronological time scale (Nilsson 1968) in northeastern Scania via varve series in western Blekinge and via Antevs' (1915) unpublished varve series from northeastern Scania. This shows that the area from the coast and 10 km northwards was deglaciated between 10,200 B.C. and 10,100 B.C. At the coast the velocity of the ice recession, according to this chronology, was estimated at 100 m/year, while it was 80 m/year in the northern part of the area investigated.

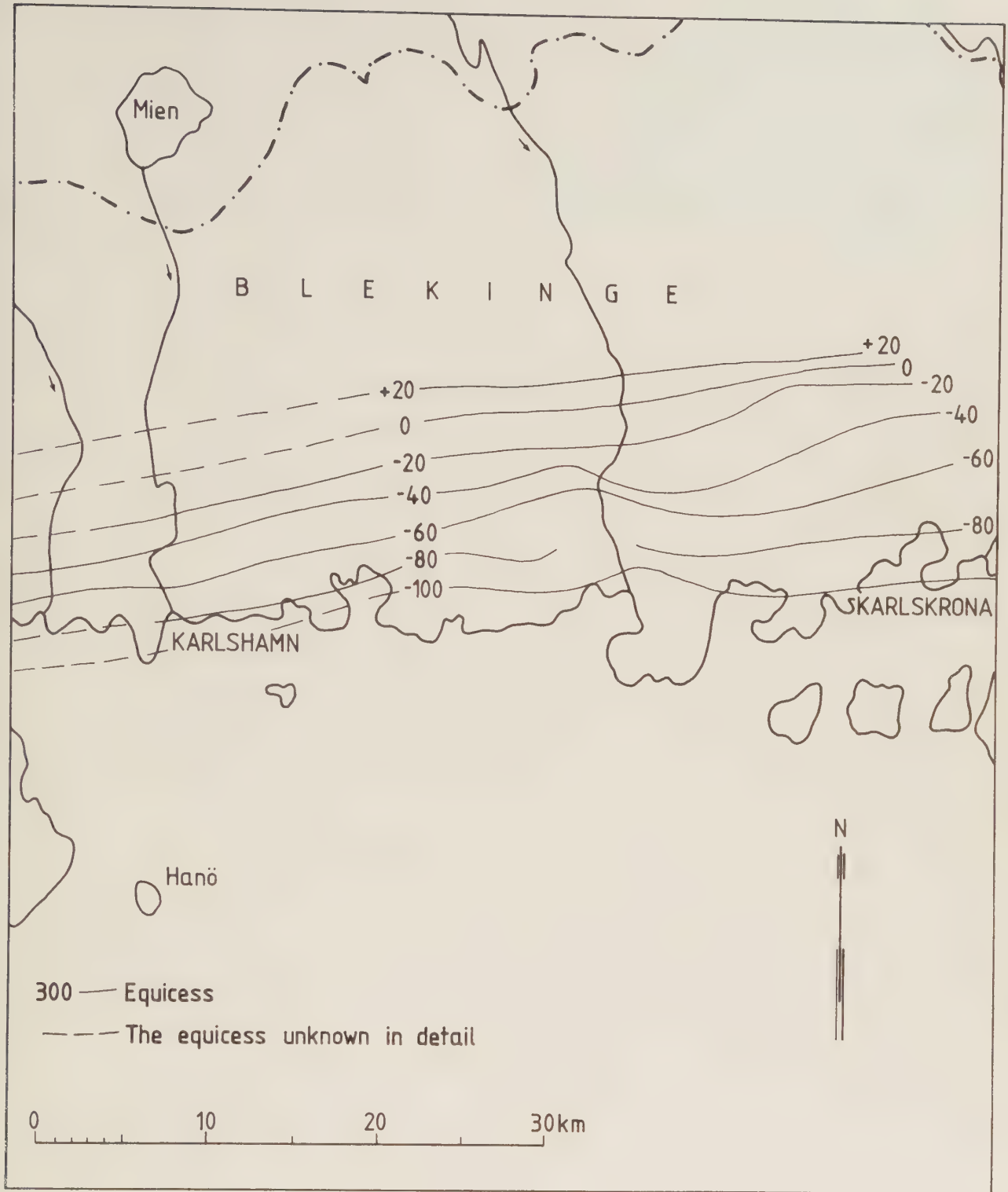


Fig. 8. Varve chronology and ice recession in central Blekinge, according to Ringberg's (1979) local time scale.

As has been pointed out in the previous section, Ringberg (1974) correlated the diffuse varve type with formation and abrasion of the lower delta surfaces, while Mörner (1975a) correlated this varve

type only with the formation of the Bredåkra delta. Due to the increasing criticism of Nilsson's time scale (1968), Ringberg (1979) established a local varve chronology for Blekinge and north-eastern Scania, ranging from the local year -325 to the local year +315 (Fig. 8). This new chronology means that the southern part of Blekinge was deglaciated between the local years -80 to +20.

There have been different opinions about the time of the deglaciation of Blekinge. Many authors, as e.g. De Geer (1910), Munthe (1910 and 1940), Johnsson (1952) and Nilsson (1968) thought that Blekinge was deglaciated during the Older Dryas period and/or correlated the Bredåkra delta with the Göteborg and Kalmar end moraines. This view of interpretation was the main reason why Berglund's (1966) shore displacement curve starts in the later part of the Older Dryas pollen zone (Fig. 7). Mörner (1969 and 1975a, b) extended the Fjärås line on the west coast down to the Bredåkra delta. This line and thus also Berglund's (1966) highest shore line was dated by Mörner (1969) to 10,300 - 10,350 B.C., corresponding to the very end of the Oldest Dryas period. Mörner (1969 and 1975b) made the correlation between the west coast and the east coast on the basis of Antevs' (1915) clay varve -100, and on paleomagnetic data, which according to Ringberg (1971 and 1976) cannot be done. According to Tauber (1970) the Göteborg - Fjärås - Bredåkra line should be placed in the Bölling period, which he dated to 10,400 - 10,100 B.C. This means that the whole of Blekinge, with the exception of the archipelago, was deglaciated during this period. Berglund (1971a) estimated the age of the boundary between the Oldest Dryas period and the Bölling period to 10,300 B.C., and thought that the Fjärås-Bredåkra line was formed during the very end of the Oldest Dryas period. However, he was uncertain about this kind of correlations (from west to east) as well as about the reliability of the Swedish time scale in Blekinge. In spite of this uncertainty he was of the opinion that the southern coast of Blekinge was ice-free during the transition from the Oldest Dryas to the Bölling period. Berglund (1976 and 1979) revised this opinion and stated that the deglaciation of southern Sweden should be related to the radiocarbon chronology, at least until the floating varve chronology in southern Sweden can be linked up with the varves north of the Swedish end moraines. This means that Berglund correlates the deglaciation with the chronostratigraphy

established by Mangerud et al. (1974) and by Mangerud and Berglund (1978). The chronostratigraphy is, according to Mangerud et al. (1974), as follows: Bölling Chronozone 13,000 - 12,000 B.P., Older Dryas Chronozone 12,000 - 11,800 B.P., Alleröd Chronozone 11,800 - 11,000 B.P. and Younger Dryas Chronozone 11,000 - 10,000 B.P. (conventional radiocarbon years before present). According to Berglund (1976 and 1979) Blekinge was deglaciated during the Bölling Chronozone, which is possibly at about the same time as the Halland Coastal Moraine and the Gothenburg Moraine were formed on the west coast.

Berglund (1966) divided the so-called 'Late-Glacial time' in Blekinge into four pollen zones: Older Dryas, Alleröd, Younger Dryas and the transition zone between the Younger Dryas and the Pre-Boreal zone. These biozones were defined by changes in the composition of the vegetation, which means that the boundaries usually reflect climatic changes. Chronostratigraphically these zones are named periods. The boundaries of these periods were related to the radiocarbon chronology: Older Dryas/Alleröd 10,100 B.C., Alleröd/Younger Dryas 8,900 B.C. and Younger Dryas /Pre-Boreal 8,300 B.C. In Berglund (1976) this chronology was revised and the pollen stratigraphy was related to the chronostratigraphic subdivision of the Weichselian (Mangerud et al. 1974).

2.3.5. The post glacial development

The water level changes of the Baltic during the Yoldia Sea, Ancylus Lake and Littorina Sea periods are a classic topic for Quaternary researchers. Already in 1882 De Geer found indications of an early regression in the Baltic basin, which was later correlated with the Yoldia Sea stage. Holst (1899) thought that the Ancylus transgression reached about 8 m a.s.l. at the south coast of Blekinge. Munthe (1902) thought that the Ancylus beach ridge in Olsäng, easternmost Blekinge, is higher than the highest Littorina ridge. Holst (1909) and Sundelin (1924) described transgressive stratigraphies at localities near the sea in Blekinge. These were correlated by Berglund (1964) with the Littorina Sea stage principally by pollen and diatom analyses at 12 localities in Blekinge. He showed the complexity of the development of the Baltic. According to him the regression during the Yoldia Sea stage could

have reached down to 40 m below sea level. The rather short Ancylus Lake stage is characterized by a transgression up to about 6 m a.s.l., after which follows a regression. The Littorina transgression complex starts at about 7,000 B.P. and lasts for more than 3,000 years. Berglund (1964) has found traces of six transgressions with the most pronounced one reaching almost 8 m a.s.l. and dated to 5,000 B.P. This period is followed by a gradual regression down to today's sea level. Berglund (1971b) paid special attention to the Littorina transgressions and according to the results from lagoon sediments of the six transgressions the complex transgression III-IV reached the highest altitude (about 7.5 m a.s.l.) and was dated to about 5,700 to 5,100 B.P. ($T_{1/2} = 5568$ years). The date of the last transgression was confirmed by Björck and Möller (1976) from an investigation in the Åbyå river valley, easternmost Blekinge, where a fluviatile accumulation phase is dated to 4,900 B.P. This accumulation is interpreted as being the result of a rising of the erosion base in the river valley, possibly caused by a transgression. Persson (1976) found that the maximum altitude of the Littorina transgression in the Ronneby area is 7.5 m a.s.l. Mikaelsson (1978) described the complex beach ridges at Olsäng, which were mentioned by Munthe in his work from 1902. Mikaelsson thought that these ridges were formed during the Ancylus transgression as well as during the Littorina transgression. He showed that the highest ridge was formed during a period when the level of the Baltic was situated between 6 and 8 m a.s.l.

Berglund (1966:II) made an extremely thorough investigation of the vegetational history of eastern Blekinge, with particular stress on the influence of man. Most of the work was based on pollen analyses. The observed vegetational changes, which were dated at nine sites by pollen analysis, were related to climatic changes, soil conditions, plant immigration and human interference.

3. STRATIGRAPHY

3.1. Biostratigraphic subdivision

All pollen diagrams have been divided into assemblage zones. These zones are defined according to Hedberg (1976) and named Local Assemblage Zones, with usually two or more prominent and diagnostic pollen types as name-givers. These zones have finally been correlated with Regional Assemblage Zones, which represent a synthesis of these Local Assemblage Zones. This means that the range of the Regional Assemblage Zones is usually wide, and they often correspond to more than one Local Assemblage Zone. The terminology and principles of the biostratigraphic units used is described in Chapter 4, section 10.6.

3.2. Chronostratigraphic subdivision and terminology

According to Hedberg (1976) a chronostratigraphic unit is 'a body of rock strata that is unified by being the rocks formed during a specific interval of geologic time. Chronostratigraphic units are bounded by isochronous surfaces.' Mangerud et al. (1974) have based their subdivision of the Pleistocene and Holocene Series strictly on Hedberg (1970 and 1971), which correspond well with the definitions established by Hedberg (1976). Mangerud and Berglund (1978) proposed a slight change of the original subdivision of the Weichselian Stage. The boundaries between the different series, stages, substages and chronozones, from the Middle Weichselian Substage right up to present time, are strictly defined by radiocarbon years ($T_{1/2} = 5568$ years and 1950 as zero-year), and when it is possible by calendar years. In this work I have kept to the chronostratigraphic subdivision by Mangerud et al. (1974) and Mangerud and Berglund (1978) based on radiocarbon years.

3.3. Lithostratigraphic subdivision and terminology

According to Hedberg (1976) a lithostratigraphic unit is 'a body of rock strata that is unified by consisting dominantly of a certain lithologic type or combination of lithologic types, or by possessing other impressive and unifying lithologic features. Lithostratigraphic units are recognized and defined by observable physical features and not by inferred geologic history or mode of

genesis.' In this work the sediments from gravel pits and boreholes have been originally divided into strata, which are described and limited by their physical features. These strata have then, for each river valley investigated, been assigned to informal local lithostratigraphic units, established on the basis of the features of the different strata found and defined according to Hedberg (1976). These units have finally been correlated with the lithostratigraphic subdivision of Blekinge (Lagerlund and Björck 1979).

4. FIELD WORK AND METHODS

4.1. Coring and sampling

As one of the main purposes of this investigation has been to date the isolation of lake basins from the Baltic Ice Lake, stratigraphical investigation of suitable basins has been the principal method of study. Of about 50 basins preliminary investigated, 33 have been investigated in more detail regarding sediment stratigraphy. The preliminary stratigraphical investigations have been carried out almost exclusively with a peat sampler named the Russian sampler of diameter 50 mm and length 1 m (cf. Jowsey 1966). In 6 basins a Livingstone piston corer with a core diameter of 100 mm and a tube length of 1.7 m has been used (modified corer described by Wright, 1967). The Russian sampler has proved very useful in mapping sediment stratigraphy and for obtaining supplementary pollen profiles not requiring ^{14}C dating. The Livingstone corer has been used in basins where ^{14}C datings and detailed analyses have been necessary, often after preliminary investigations with the Russian sampler.

Most of the coring has been carried out during winter, when the basins have been ice-covered. Apart from providing a solid platform, the ice offers ease of transport when looking for the most suitable place to core at. It is also much easier to orientate oneself on ice than in a boat. The rest of the cores have been taken from a boat/raft in open water or from a peatbog surface. The preliminary classification of the sediments was carried out immediately in the field. When varved clay has been found the varves have been counted in the field as they appear most clearly when the core is fresh. All cores have been brought to the laboratory for more detailed sediment descriptions and eventual analyses. The sediments have been classified according to the soil characterization system of Troels-Smith (1955). In some cases cores have been photographed and all basins analysed have been documented by photographs. This part of the field work was carried out between the summer of 1974 and the winter of 1977-78.

4.2. Threshold investigations of the analysed basins

Since many Swedish lakes and peatbogs have been drained by man, it has been very important to find out the original threshold level of the basins. One part of this investigation has therefore been to examine the outlets of the basins and to determine whether the water-level has been lowered. In all cases there seems to have been at least some drainage of the basin. This has either been done by digging or blasting. These observations have led to the study of old maps and documents regarding these water-level lowerings. In some cases, however, the original water-level has only been estimated by field observations. The method of estimation of the original threshold level of each basin is made clear from the site descriptions. The latitude given for the present level of each lake or bog originates from the topographic or economic map of the area. The given altitudes with a decimal have been levelled, while the altitudes without a decimal have been determined photogrammetrically or by a barometer. The threshold investigations were done in the summer of 1977.

4.3. Investigations of the lithostratigraphy of river valleys in Blekinge

As the main part of the minerogenic sediments in Blekinge is situated in the valleys, this part of the field work has been concentrated on those.

The principal part of this field work has been the description of the stratigraphy of all gravel-pits within the investigation area. This has been supplemented by more detailed investigations by myself, Lagerlund (1974), Geotifo (1975), Björck and Möller (1976 and 1977), Hebrand (1978), three Swedish students (Blomberg, Edvardson and Ohlsson) and by Schneider (a German student). Some of these investigations are mentioned in Berglund et al. (1975). These complementary investigations have resulted in detailed sub-soil maps from key areas, many important profiles and detailed sediment stratigraphy. The mapping has been carried out using a spade and a sounding rod. The distance between two mapped points has not usually been more than 100 metres in any direction and the

mapping depth has been about 50 cm. The borings have been done partly by a post auger and partly by a screw auger drill.

An important aspect of the field work has been the study of the sediment morphology. The stratigraphy of all important gravel pits has been photographed. Important morphological characters have also been photographed, especially those which are characteristic of different parts of the river valleys.

This part of the field work was carried out between the summer of 1974 and the autumn of 1978.

4.4. Studies and measurements of varved clay

Varved clay has been examined from three different situations. The most useful one for my purpose seems to be the investigation of varved clay found in lake sediments. The thickness measurement of these varved clays was made immediately in the field. In the laboratory the measurements have been checked and more detailed observations have been made, such as changes of colour, structure and granulometric changes. Measurable varved clay has been found in three lakes analysed. Varved clay has also been found in bore holes, but it has not proved possible to determine the number of varves. Varved clay has often been found in exposures in gravel pits. Mostly just a few varves were found in this way and although some of them have been measured it seems impossible to correlate them with the long varve series found in the area. Except for one locality, more than 45 varves have not been found in a gravel pit.

Usually both summer and winter layers were measured. During the latest measurements I have tried to bear in mind the possibility of the occurrence of turbidites (Shaw and Archer, 1978). Some interesting parts of the varve series have slowly been dried to study how distinct the boundaries were between summer and winter layers.

The measured value of each varve thickness has been transferred to a varve diagram with the varve number on the X-axis and the thickness of each varve on the y-axis.

4.5. Studies of aerial photographs

The whole investigation area has been studied from aerial photographs with a scale of 1:30000, and this has been useful in many ways. Several gravel pits were found by these studies, and it has proved possible to study the original morphology of the most recently exploited areas as most of the aerial photographs were taken in 1961. Important areas have been partly mapped by these studies, and together with topographic (1:50000) and economic maps (1:10000), morphological and sedimentary units have been mapped in relation to their height above sea-level. The sediment distribution has also been related to the bed-rock topography during these studies.

4.6. Determination of loss on ignition

All cores from lakes and peatbogs which were brought to the laboratory have initially been analysed regarding loss on ignition. The results from these analyses have often been a good indicator of the possibilities for further stratigraphic studies of a core. Samples taken from the core were dried at 105°C and their dry weight was calculated. The samples were then ignited at 550°C and weighed again. The loss on ignition is expressed as the weight loss after ignition in percent of the dry weight. Roughly the loss on ignition is the percentage of organic material, but it also includes some latent water of crystallization, which makes the method slightly inaccurate for sediments with extremely low organic content. The loss on ignition value has in some cases been a good aid for determining a more precise limit between two sediment types.

4.7. Determination of the magnetic susceptibility of lake sediments

The main reason why many of the sediment profiles were investigated for magnetic susceptibility was, together with many other parameters, to use it as an indicator of isolation. As pointed out by Thompson et al. (1975), changing susceptibility in lake sediments can be correlated with variations in the amount of inwashed inorganic allochthonous material present in the cores. This also means that changes in the drainage basin area can cause changing suscepti-

bility in the sediments (Dr. Thompson, personal communication). As will be shown later this correlation has been very positive.

The definition of magnetic susceptibility is according to Thompson et al. (1975) 'the ratio of induced magnetization to applied field or, more simply, a measure of the 'magnetizability' of a sample, viz. its degree of attraction to a magnet. It is largely a function of the volume of ferrimagnetic minerals in the sample.' The equipment used here was a Digico Bulk Susceptibility Unit situated at the Paleomagnetic Laboratory of the Department of Geology in Lund. The unit works on an electrical bridge principle. The samples are placed on the wooden sample holder and measurements made when the sample is pushed into the coil.

As shown by e.g. Molyneux and Thompson (1973) it is an advantage to measure single samples, because continuous core susceptibility measurements tend to smooth out any variations with a narrow depth range. My samples were taken in 5 ml plastic jars. Every sample has been measured at least twice. Tests were also carried out to check if there is any difference between wet and dried samples, but no difference was apparent. As many of the samples have only been measured wet, the water content has been determined in some cases. Changes of the water content have, however, been much too small to explain the change in susceptibility.

All samples were taken with as narrow a depth range (usually not broader than 0.5 cm) as possible from the cores. In some cases the sampling level was not the same as for the pollen samples. The reason for this was that sometimes the amount of material was insufficient for both analyses at the same level and in some cases the sampling for the susceptibility was done for other reasons than for the pollen analyses.

The unit used for volume susceptibility is 10^{-6} Gauss/Oersted (c.g.s. units), which is also the unit used in the diagrams.

4.8. Mineralogical analysis of clay

The main reason for investigating the clay in respect of the mineralogic composition is due to the varying values of the susceptibility in varved clay. In order to find out whether these

varieties are related to changes in the mineralogic composition, ten samples have been analysed with X-ray diffraction. As no qualitative differences were found, neither between different samples in the same lake nor between different lakes, in respect of their mineralogy, the samples were further investigated. The purpose for this investigation was to find out whether the susceptibility anomalies correspond to the content of the magnetite. First of all the samples were carefully suspended in distilled water. The samples were then attracted by an electro-magnet, in order to separate the magnetite particles from the suspension. This separation was made as complete as possible. Finally the extracted magnetite was weighed and related to the dry weight of the sample.

The X-ray diffraction was carried out by Research Engineer Zoltan Solyom, while the rest of the investigation was carried out by myself together with Mr. Solyom. Possibly these investigations will be followed-up later by myself in collaboration with Mr. Solyom with more detailed analyses of the chemical and mineralogical composition of the clays.

4.9. Radiocarbon analyses

31 samples have been submitted to the Radiocarbon Dating Laboratory in Lund for dating. These samples were collected from 7 different basins. Three samples have proved impossible to date, possibly due to a too low content of dateable organic material. The main purpose of the datings has been to obtain a detailed Late Weichselian chronology after the deglaciation in Blekinge. Unfortunately many of the datings have given a much higher age than expected, which will be discussed in connection with chapter 6. The samples were taken from 100 mm Livingstone cores with one exception. The samples were made as narrow as possible, usually between 3 and 4 cm thick, but when the organic content was extremely low, up to 10 cm thick samples were taken. Before submission the samples were dried in 100°C. At the Radiocarbon Dating Laboratory most of the samples were pretreated with HCl, but on the proposal of Research Engineer Sören Håkansson the later samples were not treated with HCl because of the low amount of organic material. Many samples have also been diluted with CO₂ from anthracite to allow dating.

The calculation of the radiocarbon age is based on a half-life of 5568 years for ^{14}C . The results are given in the number of years before 1950 (^{14}C -age B.P.). As a standard figure, 95 % of the activity of the NBS oxalic acid standard is used according to international agreement. All ^{14}C values are ^{13}C corrected for deviations from agreed standard value on the $^{13}\text{C}/^{12}\text{C}$ -relation ($\delta^{13}\text{C} = 25 \text{ ‰}$ in the PDB-scale). The dates are also published in the official dating lists of the laboratory (Håkansson 1979 and 1980).

4.10. Pollen Analyses

4.10.1. Sample preparation

Two kinds of methods have been used. At first the conventional method described by Assarsson and Granlund (1924) was used. It was applied in the following manner:

1. Washing with H_2O .
2. Boiling with 10 % HCl if CaCO_3 has to be removed.
3. Washing with H_2O .
4. Boiling with 10 % NaOH .
5. Washing with H_2O .
6. Treatment with 40 % HF . This was boiled and usually left standing for several days.
7. Boiling with HCl .
8. Washing with H_2O .

The procedure was completed by acetolysis as described by Faegri and Iversen (1975) and was applied as follows:

9. Washing with acetic acid.
10. Boiling with acetic anhydride + conc. H_2SO_4 (proportions 9/1).
11. Washing with acetic acid.
12. Washing with H_2O .
13. Washing with glycerine.
14. Mounting in glycerine and sealing.

Three profiles from Blekinge have been analysed in the manner described above, two of which will be discussed in this thesis.

Very soon it became obvious, however, that this method neither gave a sufficient concentration of pollen grains nor enough determinable pollen grains when dealing with extremely minerogenic sediments. Thus it became necessary to find a better way to concentrate and clean the samples. After a couple of months of experiments a method, named the ZnCl_2 -method, was developed. It is described in detail by Björck et al. (1978) and can be summarized as follows:

- 1-5. are the same as described above.
6. Stir or shake thoroughly with 5 % $\text{Na}_4\text{P}_2\text{O}_7$. Let the sample stand in this solution for up to one day.
7. Wash with H_2O .
8. Add a concentrated ZnCl_2 solution into two test-tubes which are filled with H_2O to make certain that the density is low enough for pollen and spores to settle during the following centrifugation. The ZnCl_2 treatment should be repeated at least three times.
9. Wash with H_2O .
10. Boil for about 5 minutes in HF.

After this follows 7-14. described for the previous method. Björck et al. (1978) also made a comparison between the two above described methods and the ZnCl_2 -method seemed to have so many advantages that all pollen-analysed profiles connected with this thesis, except the two mentioned, were prepared in this way.

4.10.2. Pollen analysis

All microfossils were counted using a Leitz Laborlux microscope at a magnification of $\times 300$, using $\times 8$ Periplan oculars, a $\times 40$ apochromatic objective (numerical aperture = 0.85). Critical examinations and identifications were made with an apochromatic oil-immersion objective ($\times 90$ and numerical aperture = 1.32).

To avoid any errors associated with random pollen distributions the slides have been analysed along equally spaced traverses. The number of traverses required was assessed after an initial examination of the slide.

4.10.3. The pollen sum

As previously mentioned, the analysed profiles were low in organic material and thus poor in pollen and spores. The original aim was to count between 500 and 1000 pollen grains of terrigenous spermatophytes on each level. Unfortunately the number of pollen grains was much too sparse in some of the samples to be able to reach 500 grains without excessive effort. With the exception of a few levels the number of pollen grains has exceeded 250. As the main purpose of the pollen analyses was to date certain events, and not to establish a detailed vegetational history of the area, the number of pollen grains counted has usually been sufficient, especially considering that all the pollen diagrams are from the same area.

4.10.4. Pollen diagrams

The profiles were analysed for pollen grains and spores of vascular plants, *Sphagnum*, some algae and a few other identifiable micro-fossils. The results are presented in diagrams. Not all pollen and spore types found are, however, included in these diagrams. The diagrams are mainly used as a tool for chronostratigraphic/biostratigraphic correlations.

The diagrams are constructed in the same general way as other Danish and Swedish investigators have done when dealing with Weichselian sediments (cf. Iversen 1954, Krog 1959, Andersen 1961, Berglund 1966 and 1971). The pollen diagrams do not reflect the extra local plant communities (i.e. aquatic plants) of the basin, but a more regional picture. The size of this area is often related to the size of the basin. No corrections to counteract the effect of differential pollen production and dispersal have been made. The pollen diagrams have a uniform format to permit ease of comparison. On the extreme left the depth below water surface is given. Then follows number of pollen sample. The column for number of layer is situated to the left of the lithostratigraphical column. The sediment lithology is represented diagrammatically by the symbols proposed by Troels-Smith (1955). After this follow the columns for the micro-fossils in the following way.

A. Terriphytic spermatophytes

- a. Trees - Betula spp. (excluding B. nana), Pinus, Populus,
Prunus, Sorbus, Corylus, Ulmus
- b. Shrubs - Betula nana, Hippophaë, Juniperus, Salix
- c. Dwarf-shrubs - Empetrum, Ericaceae
- d. Herbs and graminids - Artemisia, Chenopodiaceae, Dryas,
Filipendula, Rumex acet. coll., Thalictrum, Cyperaceae,
Gramineae

To the left is a composite total diagram which illustrates the relative proportions between groups a. and d.

To the right of the column for ΣA follows:

- B. Terriphytic pteridophytes (Lycopodium spp.)
- C. Limnophytes (Myriophyllum spp., Ranunculus sect. Batrachium and Isoetes spp.)
- D. Telmatophytes (Equisetum)
- E. Sphagnum
- F. Green algae (Pediastrum and Botryococcus colonies)
- G. Secondary pollen grains. "Hystrix" is also included in this group. They are, according to Iversen (1936), rebedded cysts of hystrichosphaerids.

Physical analysis (loss on ignition, susceptibility and radio-carbon dates).

Pollen assemblage zones (local zones for every basin).

Designations for the local pollen assemblage zones.

Chronozones according to Mangerud et al. (1974).

To the extreme right a column for number of the pollen sample is repeated.

The curves for Betula spp., Pinus and Corylus are given with the usual symbols, while all the other micro-fossil curves, except

Cyperaceae and Gramineae, are presented in a resolved diagram with a silhouette curve for each type. The black curves indicate actual percentages relating to the scales at the top of the diagram while the unshaded curves are exaggerated ten times. The minimum value for the black curve is either 0.5 % (Sannen, Årsjön, Kroksjön, Dönhultagyl, Lilla sjön, Galtsjön, f.d. Paddegölen, Norrsjön and f.d. Togölen) or 1.0 % (Vitavattsgyl, Logylet, Halsjön I and II, Getsjön and Bredsjön). The percentages of the terriphytic spermatophytes (A) are calculated as % of ΣA while the percentages of the other micro-fossils are calculated as % of $\Sigma A + x$.

4.10.5. Identifications

As the aim of this work has not been to study the vegetational development of the investigation area, determination of pollen and spores to the lowest possible taxonomic level has not always been necessary. Only very rarely have pollen and spores been quite indeterminable in the profiles prepared according to the $ZnCl_2$ -method, but when it has occurred, the position of the grain has been recorded. Identification problems were more common in the samples only prepared with the traditional HF-method. Of importance for understanding the pollen and spore morphology of Scandinavian plants have been works like e.g. Erdtman et al. (1961) and Faegri & Iversen (1975) etc. Illustrative pollen photos in many of the works have been very valuable. Modern reference material from the collection in the Quaternary Department of Lund University has been used, and this collection has been of great help when identification problems have arisen. The most valuable aid has, however, been the great experience of pollen analysis that exists at the Dept. of Quaternary Geology in Lund.

4.10.6. Zonations of the pollen diagrams

There are three main reasons for dividing each pollen diagram into smaller units. They are easier to describe, compare and date. As previously mentioned, many of the radiocarbon dated samples have given much older ages than expected, and it has been necessary to use relative chronology based on pollen assemblages for some profiles, which can then be correlated with reliable ^{14}C -dated sections.

Normally pollen diagrams are divided into pollen zones, which generally correspond with biostratigraphic units. According to Hedberg (1976, C1) a biostratigraphic unit is 'a body of rock strata unified by its fossil content or paleontological character and thus differentiated from adjacent strata. A biostratigraphic unit is present only within the limits of observed occurrence of the particular biostratigraphic features on which it is based', but as Quaternary pollen zones usually are characterized by the occurrence of a number of pollen types, Birks (1973) defined his pollen zones as 'a body of sediment with a consistent and homogeneous fossil pollen and spore content that is distinguished from adjacent sediment bodies by differences in the kind and frequencies of its contained fossil pollen grains and spores'. This definition corresponds most closely to an assemblage zone, which is defined by Hedberg (1976, D2a) as 'a body of strata whose content of fossils, or of fossils of a certain kind, taken in its entirety, constitutes a natural assemblage or association that distinguishes it in biostratigraphic character from adjacent strata'. It is important also to know how Hedberg (1976, D2a) amplifies the nature of the assemblage zone. 'An assemblage zone may be based on all kinds of fossil forms present, or it may be restricted to forms of only certain kinds. Whatever its basis, an assemblage zone is characterized by an assemblage or association of fossil forms that are assumed to have lived together or to have died together or to have accumulated together, or, in any case, to have entombed together. The assemblage zone is particularly significant as an indicator of environment. Regardless of interpretation, it is an observable, relatively objective biostratigraphic unit of high value in local correlation'. As far as the naming of the assemblage zones is concerned Hedberg (1976, D2c) further states that 'the name of an assemblage zone should preferably be derived from two or more of the prominent and diagnostic constituents of the fossil assemblage'.

In this study the local pollen zones have been termed local pollen assemblage zones and unlike e.g. Birks (1973) named only by terriphytic spermatophyte pollen grains. The reason for this is the often very high values of reworked spores abundant in many of the analysed profiles. Reworked pollen grains have been named 'secondary pollen grains' and this designation has in some cases been used as a complement to the proper name of the local pollen assemblage zones.

The order in which the different pollen types are written in the name of the pollen assemblage zone (p.a.z.) is the order of supposed significance. The division of the pollen diagrams into local pollen assemblage zones has been in accordance with Hedberg (1976). These have been synthesised to produce regional pollen assemblage zones. These have also been named and defined in accordance with Hedberg (1976). The probability that they represent valid regional pollen assemblage zones is high because of the rather large number of analysed profiles within a relatively restricted area.

Apart from this present study, the work of Berglund (1966) is very important in considering the relationship between chronology and pollen zonation. Although Berglund principally zoned his pollen diagrams with respect to vegetational and climatical changes, the division of the diagrams in this study is often very similar to those made by Berglund (1966). Other works as e.g. Berglund (1971 and 1976), Bjelm (1976), Iversen (1954 and 1973), Mangerud et al. (1974) and Nilsson (1961) have also been important for establishing an absolute chronology related to the pollen zonation.

Every local p.a.z. has been given an abbreviation of one or two letters (first and in some case second letter in the name of the basin in question) followed by a figure. This figure represents the numerical position of the zone in question, starting from the bottom of the profile going upwards. Finally all the local pollen assemblage zones have been put together in two tables and related to the absolute chronology. These chronostratigraphic correlations have resulted in the regional pollen assemblage zones.

4.11. Diatom analyses

Some of the lake sediment cores have been analysed in respect of the diatom content. The purpose for this was originally to find out if changes of the composition of the diatom flora support the already interpreted isolation levels. A main question has been whether the isolation from a big ice lake environment with probably fresh water to a small fresh water lake causes any change at all in the diatom composition. The samples, which were all prepared and analysed by Mrs. Hannelore Håkansson, were usually very rich in minerogenic matter and thus very hard to prepare as well as to

analyse. The preparation procedure was as follows:

- 1/ The samples were heated in HCl and washed with H₂O.
- 2/ The samples were heated in H₂O₂ at a temperature of 50-60°C.
- 3/ Repeated decanting to let the coarser particles settle.

In the preparation Microps was used as the mounting medium. The analysis was carried out by using phase contrast equipment. The aim has been to count at least 200-300 valves at each sample level. However, this was in all but six samples shown to be impossible. The grouping of the diatoms has been carried out by Dr. Gunnar Digerfeldt.

4.12. Numerical methods

In the spring of 1977 Dr. John Birks visited the Department of Quaternary Geology in Lund. One of his main tasks was to introduce numerical methods into Swedish pollen analysis and to show how they should be applied to stratigraphical material. This was, of course, very exciting, so most of the pollen-analysed profiles in this thesis have been tested in respect of some of the methods introduced by Dr. Birks.

The method most used has been principal component analysis (PCA). PCA is a statistical technique for describing the interrelations of a large number of correlated variables in terms of a smaller number of uncorrelated variables that are linear combinations of the initial variables. The object of the analysis is to reduce the dimensionality of the problem under study and thus clarify the patterns that are present in the data. This powerful and versatile numerical scaling or ordination technique has been frequently used to detect structure or patterns within Quaternary pollen-stratigraphic data (Adam, 1974; Birks, 1974; Pennington and Sackin, 1975; Birks and Berglund, 1979). The mathematics of the method are described by Morrison (1967), Davis (1973) and Jöreskog et al. (1976). The FORTRAN IV program PCARMODE written by Dr. Birks was modified for the computer of Datacentralen in Lund. The main use of this method was to compare my zonations of the pollen diagrams with the zonations determined by PCA. Many profiles have been zoned with PCA in respect of changes of the terriphytic spermatophyte flora. At some sites, these zonations have been compared with the

established local pollen assemblage zones. Some of the profiles have been zoned with respect to isolation problems. In these cases either data for all taxa in the diagrams were used as input to the computer or just the supposed isolation indicators. Some of these zonations will be considered in the chapter that presents the isolation problems. The PCA results have not been the basis of my interpretations, but they have provided useful means of surveying a large amount of material. PCA has also in some cases clearly shown the existence of transition zones between two well defined zones. The data given to the computer are the percentages on which the pollen diagrams are based.

Another numerical method that has been used is slotting of sequences. This is a method that tries to slot together stratigraphical sequences where the ordering of the samples is an important constraint. Gordon & Birks (1974) described and applied this method to fossil pollen sequences. When comparing two fossil pollen sequences, it is necessary to know which interval of the other core each level resembles. One can define a measure of dissimilarity between all pairs of levels, and say that a level fits satisfactorily between a pair of levels in the other core if its dissimilarity with both of them is satisfactorily low. The aim is to slot together two sequences so that there are good local fits, subject to the overall constraints imposed by the stratigraphical orderings. The statistics concerning slotting of sequences are described in Gordon (1973). The FORTRAN IV program SLOTSEQ was written by Dr. A.D. Gordon and later modified for the computer of Datacentralen in Lund by Dr. Birks. The slotting method has mainly been used to compare undated profiles with radiocarbon-dated sequences. This was done to see if the slotting results support the datings made just by correlations of pollen assemblage zones. For this method the raw pollen counts were used as input to the computer.

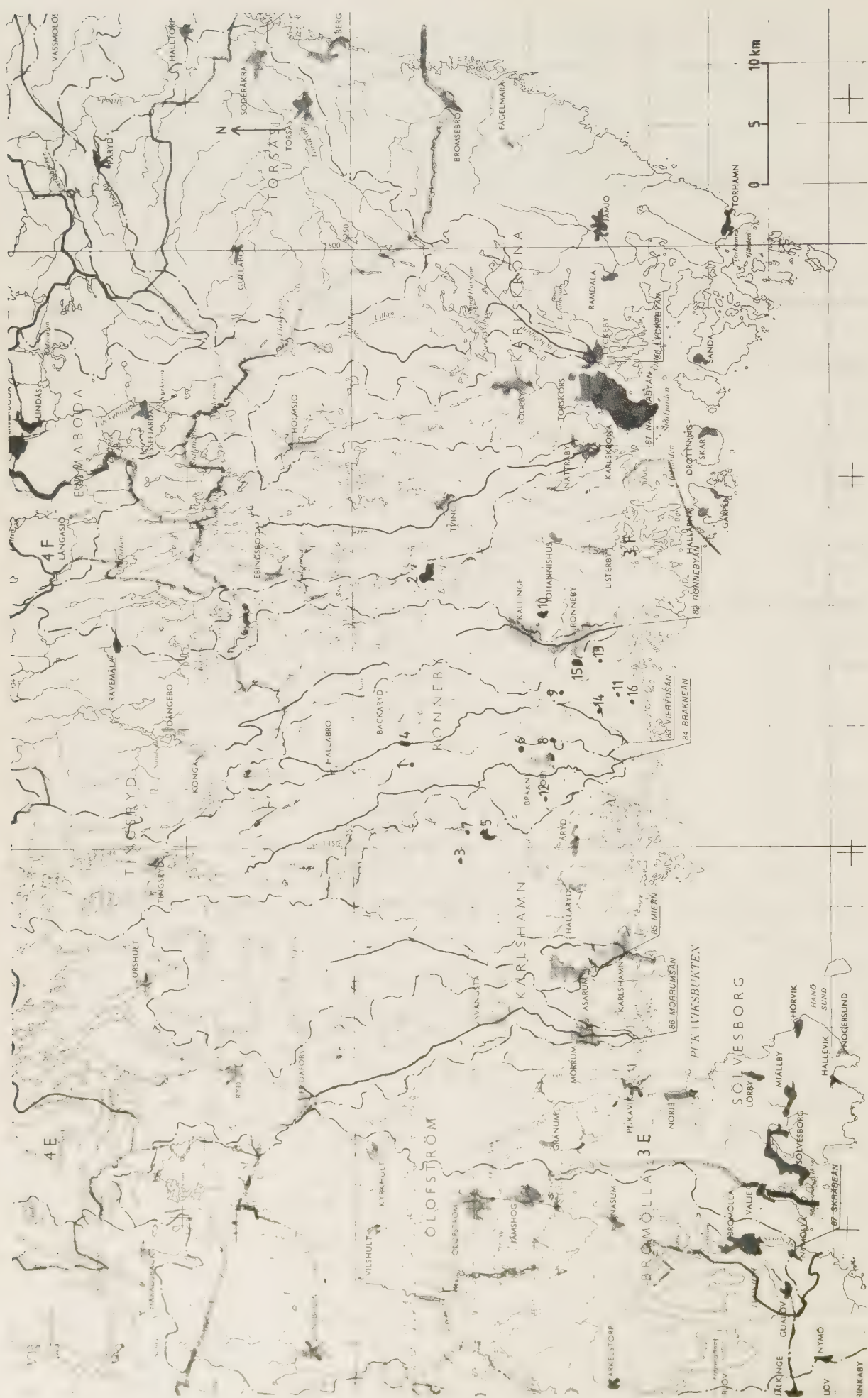


Fig. 9. Map showing the geographical position of the basins investigated

5. DESCRIPTION AND STRATIGRAPHY OF THE INVESTIGATED BASINS

The locations of the basins are shown in Fig. 9. They are described in sequence from the highest basin to the lowest. The distance figure after the name of the site on the pollen diagrams is the distance from latitude $56^{\circ}10'N$, which is approximately the location of the coast line in the area. The height figure given in the pollen diagram is the estimated original water level of the basin. Depth figures in the stratigraphic descriptions refer to levels below present-day lake surface. The determination of the isolation level in the profiles analysed will be included in this chapter, and the isolation level is shown by an arrow left of the diagrams, but the use of the microfossils as indicators of isolation is discussed in Chapter 7. The relation of the zonation of the diagrams to chronozones will be included in Chapter 6.

5.1. Vitavattsgyl (1)

5.1.1. Description of the site

This lake is located 3 km WSW of Backaryd and 17 km north of the coast (Fig. 9). The lake, Vitavatten, which lies north of Vitavattsgyl, has probably been connected with Vitavattsgyl. The water level of Vitavatten is, according to the topographic map, situated 70 m a.s.l. The threshold consists of bed-rock and till and the channel that now exists as an outflow is almost 1 m deep. The original level of the whole basin is therefore estimated to about 71 m a.s.l.

Vitavattsgyl is surrounded by markedly uneven terrain, reaching altitudes of more than 90 m a.s.l., dominated by till and some bed-rock exposures. The lake is situated just between the Bräkneå river valley and the Vierydså river valley. Large parts of Vitavattsgyl consist of schwing moore.

5.1.2. Sediment stratigraphy

The coring was carried out in the summer of 1974 with a Russian sampler. The sampling point is situated in the middle of the basin and the coring took place on the schwing moore, not far from

the open water. All depth figures refer to depth below the schwing moore surface, which is approximately the same as the water surface. The sediments between 0.0 and 7.0 have not been investigated.

700 - 737 cm	Layer 4. Fine detritus gyttja, brown. Composition: Ld 4. Lower boundary gradual.
737 - 773 cm	Layer 3. Clay gyttja, grey-brown. Composition: As 3, Ld 1. Lower boundary sharp.
773 - 785 cm	Layer 2. Slightly muddy clay, green-grey. Composition: As 4, Ld 0.5. Lower boundary diffuse.
785 - 800 cm	Layer 1. Sandy, clayey silt, grey. Composition: Ag 3, As 1.

Varved clay has not been found in the sediments from Vitavattsgyl.

5.1.3. Pollen stratigraphy

The analysed profile in Fig. 10 represents the sediments between 7.90 and 7.30 metres below the schwing moore surface. Within these 60 cm, 13 levels have been analysed. The pollen diagram has been divided into seven local pollen assemblage zones (V1-V7).

- V1 790 - 777.5 cm. This zone, the lowermost recorded from Vitavattsgyl, is characterized by high values of herb and tree pollen. The frequency of Pinus pollen varies between 25 and 50 %. Among herb pollen, the grass pollen types are dominant, reaching values between 17 and 23 % in total. Salix pollen is totally dominant among shrub pollen, reaching frequencies between 4 and 13 %.
The zone is named the PINUS - BETULA undiff. - SALIX - GRAMINEAE - CYPERACEAE Local Assemblage Zone.
- V2 777.5 - 772.5 cm. Characterized by high values of Artemisia (11 %) and Rumex pollen (10 %). The value of Pinus pollen decreases compared to zone V1, as do also grass and Salix pollen.
This zone is named the ARTEMISIA - RUMEX Local Assemblage Zone.

- V3 772.5 - 762.5 cm. Characterized by abundant tree pollen, with the two tree pollen types together reaching values between 75 and 80 %. There is no other pollen type characteristic of this zone.
The zone is named the BETULA undiff. - PINUS Local Assemblage Zone.
- V4 762.5 - 752.5 cm. This zone is characterized by extremely high values of Pinus (53 to 63 %) and Empetrum pollen (7 to 13 %). Compared with zone V3, Betula undiff. and Salix pollen decrease conspicuously. The herb pollen values are very low.
The zone is named the PINUS - EMPETRUM Local Assemblage Zone.
- V5 752.5 - 737.5 cm. Compared with zone V4, this zone is characterized by increasing herb pollen values and decreasing Pinus and dwarf-shrub pollen frequencies. Among the herb pollen, Artemisia (more than 5 %) and Gramineae pollen (about 10 %) are dominant. Chenopodiaceae pollen reaches values between 1 and 2 %. The only characteristic shrub pollen type for this zone is Juniperus pollen.
This zone is named the ARTEMISIA - GRAMINEAE - JUNIPERUS - CHENOPODIACEAE Local Assemblage Zone.
- V6 737.5 - 732.5 cm. Characterized by high values of Empetrum pollen, which reaches a value of 14 %. Compared to zone V5, Juniperus pollen increases further, reaching a frequency of more than 5 %. Grass pollen is the only pollen type, with the exception of those two mentioned, that reaches comparatively high values.
The zone is named the EMPETRUM - JUNIPERUS Local Assemblage Zone.
- V7 732.5 - 739 cm. This zone, the uppermost recorded from Vitavattsgyl, is characterized by abundant tree pollen, with Betula undiff. pollen dominant, reaching a value of 63 %. All other pollen types, except Filipendula, decrease in this zone, compared with zone V6.

This zone is named the BETULA undiff. - PINUS Local Assemblage Zone.

The sediments from Vitavattsgyl have not been radiocarbon dated.

5.1.4. Determination of the isolation level

According to Ringberg (1971) this basin is situated about 5 m above the highest shore line. This is also supported by the microfossil content of the profile analysed. The values of Pediastrum colonies are already high in the lowermost samples. The Isoëtes and Sphagnum spores never reach high frequencies, and the values of secondary pollen grains are much lower than is typical for basins connected with the Baltic Ice Lake (compare with e.g. site 2, 3, 5 and 8). This means that Vitavattsgyl has never been part of the Baltic Ice Lake, but is situated above the highest level the ice lake ever reached.

5.2. Sännen (2)

5.2.1. Description of the site

Sännen is one of the largest lakes within the investigation area. It is situated 17 km from the coast and 13 km NNE of Ronneby (Fig. 9). The lake is nowadays situated 62.7 m a.s.l. No evidence for a lowering of the water level has been found in either old documents or from the oldest economic maps. Without doubt, however, the threshold, situated in the north-western corner of the lake and consisting of sand, has been deepened. From field observations the deepening of the threshold has been estimated at about 1.5 m, which makes an original level of about 64 m a.s.l. probable.

The area north-west of the lake is rather flat and consists mostly of gravel and sand. North, east and south of the lake till dominates and covers areas situated 75-100 m a.s.l. The till is often very rich in boulders. The bed-rock is also exposed here and there.

Ringberg (1971, p. 114-115) described a highest shore line 1.5 km west of the coring point in Sännen at the northern part of Lister-sjön with an estimated level of 65.5 m a.s.l.

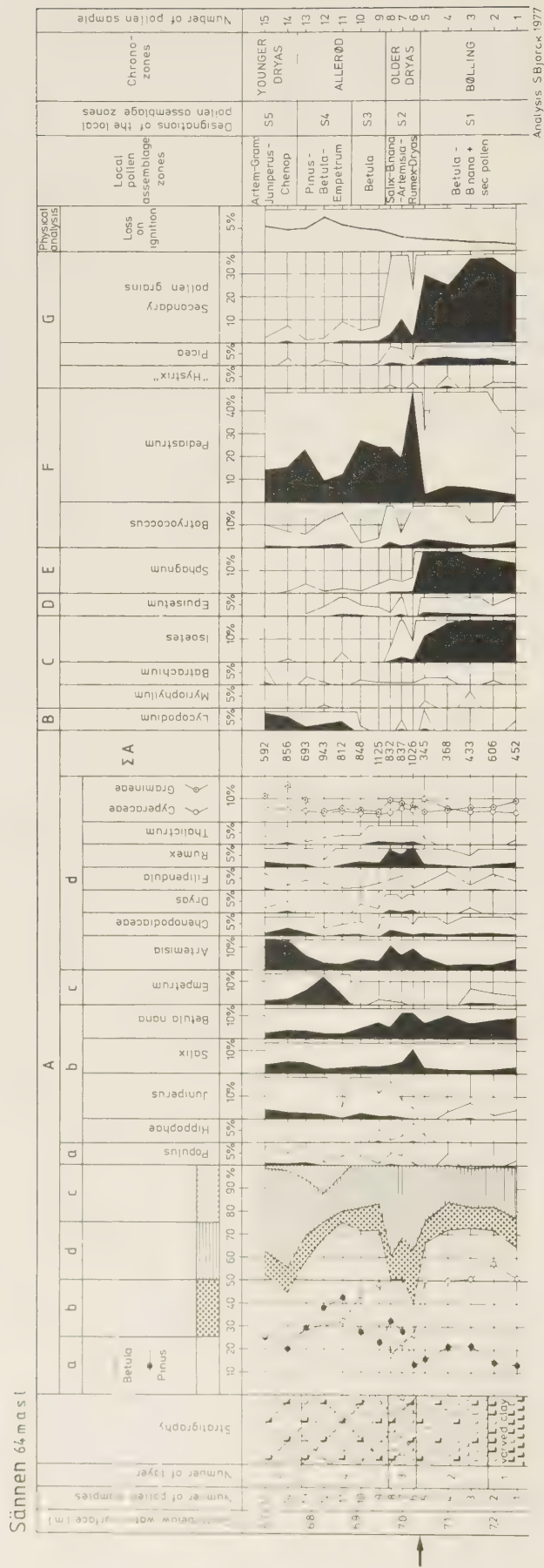


Fig. 11. The pollen diagram from Lake Sännen.

5.2.2. Sediment stratigraphy

In the winter of 1976 four preliminary cores were taken with a Russian sampler. The water depth varied between 4.20 and 3.65 m. Finally the point with the thickest sequence of deposits was chosen. It is situated 125 m west of the island occurring in the lake with a water depth of 3.65 m. The sediments to 6.45 metres below water surface were not examined.

645 - 660 cm	Layer 6. Slightly sandy fine detritus gyttja, brown. Composition: Ld 3, As 1. Lower boundary gradual.
660 - 678 cm	Layer 5. Muddy silty clay, grey. Composition: Ag 2, As 2, Ld 0.5, Th+. Lower boundary gradual. Plant remains between 6.75 and 6.78 m.
678 - 697 cm	Layer 4. Clayey silty gyttja, brownish grey. Composition: Ag 2, As 1, Ld 1, Th+. Lower boundary diffuse. Plant remains between 6.78 and 6.80 m.
697 - 703 cm	Layer 3. Muddy silty clay, light-grey. Composition: Ag 3, As 1, Ld 0.5, Th+. Lower boundary sharp. Plant remains at 7.00 m.
703 - 719 cm	Layer 2. Clayey sandy silt, grey. Composition: Ag 3, As 1. Lower boundary gradual.
719 - 745 cm	Layer 1. Varved silty clay, reddish brown-grey. Composition: As 3, Ag 1.

The varved clay consists of about 50 varves, but these have not been counted as they are often difficult to distinguish from each other. Layer 6 is not included in the diagram (Fig. 11).

5.2.3. Pollen stratigraphy

The profile analysed from Sannen represents the sediments from 7.25-6.70 metres below water surface. Within these 55 cm, 15 levels have been analysed and the profile has been divided into five local pollen assemblage zones (S1-S5). The pollen diagram is shown in Fig. 11.

- S1 725 - 702.5 cm. This is the lowest zone recorded in the sediments. It is characterized by high values of Betula undiff. pollen with frequencies of 50 % or more. B. nana pollen attains values of 10 % or more while the values of herb pollen are rather low. The values of secondary pollen grains are high throughout the zone, with Corylus and Alnus pollen dominant.
The zone is named the BETULA undiff. - BETULA NANA + secondary pollen grains Local Assemblage Zone.
- S2 702.5 - 696.25 cm. Characterized by abundant herb pollen together with high values of shrub pollen. The values of Salix and B. nana pollen attain frequencies of 10 % or more. Rumex pollen reaches values between 6 and 9 %. Together with Dryas pollen (about 1 %) these pollen types reach their highest values within this zone. Artemisia pollen is prominent throughout the zone. The decrease in the values of Betula undiff. pollen and secondary pollen grains is very pronounced.
This zone is named the SALIX - BETULA NANA - ARTEMISIA - RUMEX - DRYAS Local Assemblage Zone.
- S3 696.25 - 689 cm. Within this zone the increase of Betula undiff. pollen to values of more than 40 % is the only important change. The values of all other pollen types, except Juniperus pollen, decrease.
The zone is named the BETULA undiff. Local Assemblage Zone.
- S4 689 - 677 cm. This zone is characterized by high values of Pinus and Betula undiff. pollen. Together they attain values of 50 to 70 %. High values of Empetrum pollen, with a maximum value of 12 %, are also features of the zone.
This zone is named the PINUS - BETULA undiff. - EMPETRUM Local Assemblage Zone.
- S5 677 - 670 cm. Characterized by abundant herb pollen with Artemisia (more than 18 %) and Gramineae pollen (more than 15 %) dominant. Juniperus and Chenopodiaceae pollen reach their highest values (3 to 4 %), while the values of tree

and dwarf-shrub pollen decrease rapidly.

The zone is named the ARTEMISIA - GRAMINEAE - JUNIPERUS - CHENOPODIACEAE Local Assemblage Zone.

No radiocarbon analyses have been carried out on the sediments in Sännen.

5.2.4. Determination of the isolation level

Sännen is situated just below the highest shore line in the area (Ringberg, 1971). This means that it could have been connected with the Baltic Ice Lake for at least a short time-period. Layers 1 and 2 are very similar in type to sediments usually associated with the Baltic Ice Lake. As can be seen in the diagram (Fig. 11) substantial changes occur between samples 5 and 6. The very sudden decrease of Isoëtes, Sphagnum and secondary pollen grains with the increase of Pediastrum are also most noticeable. The loss on ignition value also rises and "Hystrix" disappears almost completely.

The very obvious change between layers 2 and 3 or zones S1 and S2 is considered to reflect the isolation of Sännen from the Baltic Ice Lake.

5.3. Logylet (3)

5.3.1. Description of the site

This small lake is located 1 km SW Halahult, 15 km NNE Karlshamn and 14 km from the coast (Figs. 9, 12 and 13). It is situated 60 m a.s.l. and no evidence has been found, neither in old documents nor from the old economic map, that the lake has been lowered. The outflow of the basin is situated in the very eastern part of the lake, and the threshold, which is situated at the outflow, consists of till. The outflow channel as well as the threshold has most likely been deepened by man. This should have lowered the lake between 0.5 and 1.0 m, which means that the original level of the lake is estimated to about 61 m a.s.l.

The lake is situated in a small bed-rock dependent valley and the shores consist mainly of steep bed-rock slopes. Apart from bed-rock the surrounding hummocky landscape is dominated by till, often with a

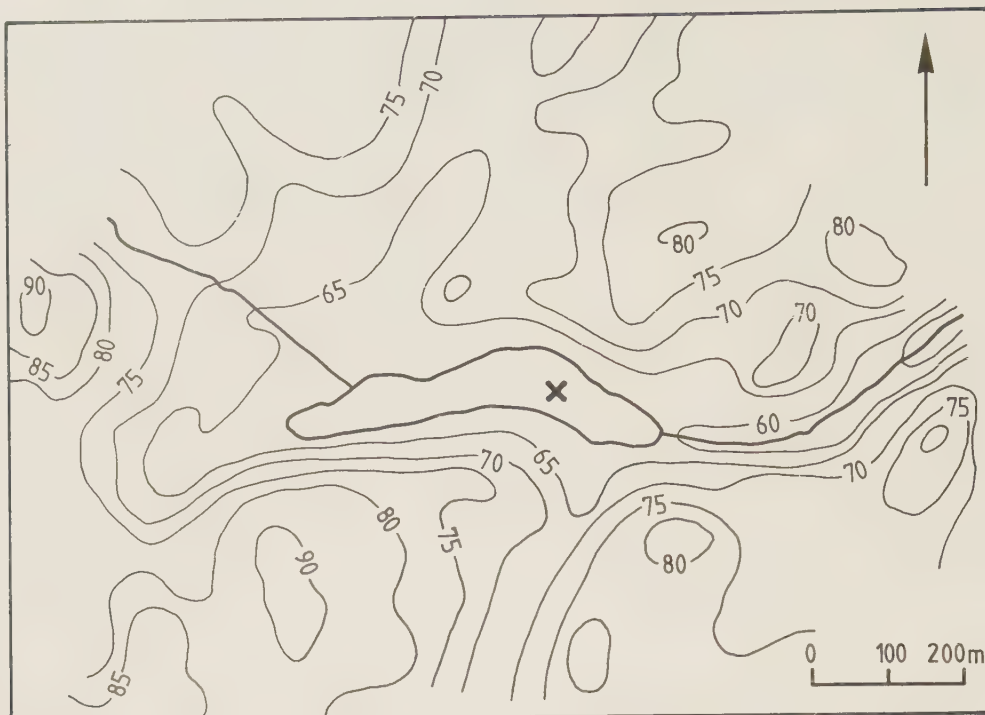


Fig. 12. The local topographic position of Lake Logylet. The cross marks the coring point.



Fig. 13. Lake Logylet seen from the outflow area towards the east and the coring point.

morphology of its own. The nearest surroundings reach altitudes of almost 100 m.

5.3.2. Sediment stratigraphy

Between the winter of 1976 and the summer of 1978 five corings have been carried out in this lake. The first core was taken with the Russian sampler and its sediment stratigraphy is shown in Fig. 15. The stratigraphy described below (Fig. 16) derives from a 100 mm Livingstone core taken in the summer of 1978, and as it resembles the stratigraphy from all the other cores very much and also has the most detailed sediment description it will represent the sediment stratigraphy from Logylet. This coring point as well as all the others is situated 150 m WNW the outflow, where the water depth is 5.5 m. The sediments between 5.50 and 9.64 metres below the water surface were not classified.

964	-	969	cm	Layer 10. Fine detritus gyttja, dark-brown. Composition: Ld 4.
969	-	977	cm	Layer 9. Clayey gyttja, greenish brown-grey. Composition: Ld 2, As 2. Lim. sup. 1
977	-	995.5	cm	Layer 8. Muddy clay, green-grey. Composition: As 3, Ld 1. Lim. sup. 2. This layer is characterized by a high frequency of green laminae.
995.5	-	997	cm	Layer 7. Clayey gyttja, green-brown. Composition: As 2, Ld 2. Lim. sup. 1
997	-	1020.5	cm	Layer 6. Clay gyttja, brownish green-grey. Composition: As 3, Ld 1. Lim. sup. 2. This layer is characterized by many green laminae.
1020.5	-	1030	cm	Layer 5. Muddy clay, green-grey. Composition: As 4, Ld 0.5. Lim. sup. 4
1030	-	1035	cm	Layer 4. Slightly muddy clay, grey. Composition: As 4, Ld+. Lim. sup. 4
1035	-	1038	cm	Layer 3. Clay, grey. Composition: As 4. Lim. sup. 1
1038	-	1045	cm	Layer 2. Slightly silty clay, red-grey. Composition: As 3, Ag 1. Lim. sup. 0
1045	-	1125	cm	Layer 1. Varved clay, red-grey winter laminae and grey summer laminae. Composition: As 2, Ag 2. Lim. sup. 0

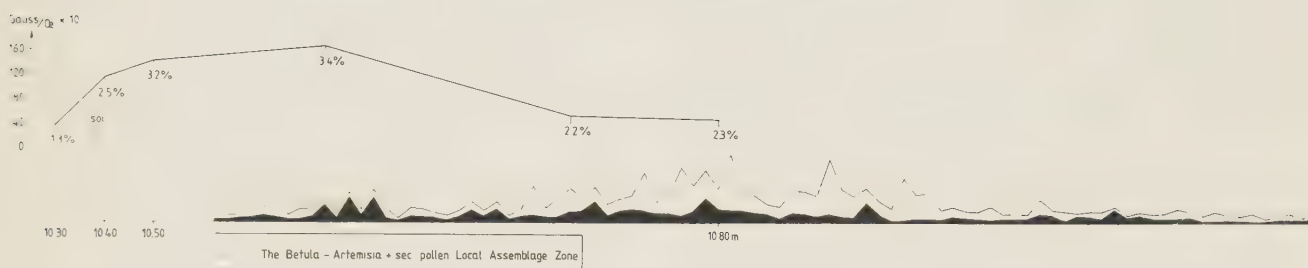


Fig. 14. Diagram of annual varves (thickness scale 1:3) from Lake Logylet, related to the pollen zonation, values of the magnetic susceptibility and the magnetite values (in % of dry weight). The black colour represents the summer layers.

Altogether 90 varves have been measured in the varved clay (layer 1), but as the twenty to thirty uppermost varves were impossible to measure it means that layer 1 contains at least 110 years deposition of varved clay. The varve diagram is shown in Fig. 14, but as it has been extremely difficult to link it with the local varve chronology (Ringberg 1979) as well as with the varved clay from Kroksjön (site 5) no dates are given in the diagram. The X-ray diffraction of the varved clay shows that it is composed mainly of quartz, clorite, illite, albite, microcline and kaolinite and that the composition is the same for the whole varved clay sequence. In Fig. 14 the susceptibility values as well as the magnetic values (in %) are related to the varve diagram, which in its part is related to the Local Pollen Assemblage Zone Lo1.

5.3.3. Pollen stratigraphy

Two profiles have been analysed from Logylet (Figs. 15 and 16). In Fig. 15 the original pollen diagram, cored with a Russian sampler, from this lake is shown, while Fig. 16 is a more detailed diagram from the last obtained 100 mm Livingstone core. In the pollen diagram in Fig. 15 22 levels have been analysed comprising 105 cm, while the pollen diagram in Fig. 16 comprises 85 cm with 20 sample levels. A third core has been analysed below and above the boundary between zones Lo3 and Lo4 for the purpose of radiocarbon dating this level. The two diagrams have been divided into the same eight local pollen assemblage zones (Lo1 - Lo8) due to the great similarities between these two pollen profiles. It should, however, be pointed out that the diagram in Fig. 16 has been analysed in the light of the investigations carried out by Usinger (1977), who believes that a majority of the Betula spp. pollen grains during pre-Alleröd and Alleröd time consist of Betula nana pollen grains.

Lo1 1090 - 1077.5 cm and 1070 - 1038 cm. This is the lowest zone recorded from Logylet. It is characterized by high frequencies of Betula undiff. pollen (between 15 and 45 %). The Artemisia pollen values are relatively high, while Pinus and Juniperus pollen reach their minimum values within this zone. Secondary pollen grains attain values between 15 and 25 %.

This zone is named the BETULA undiff. - ARTEMISIA + secondary pollen grains Local Assemblage Zone.

Lo2 1077.5 - 1062.5 cm and 1038 - 1030 cm. Characterized by abundant shrub and herb pollen. The values of Salix pollen attain frequencies between 15 and 35 %. B. nana pollen reaches values of more than 20 %. Hippophaë pollen is very typical for this zone. Cyperaceae, Artemisia and Rumex pollen are dominant among the herb pollen types. The tree pollen values as well as the frequency of secondary pollen grains decrease compared to zone Lo1.

The zone is named the SALIX - BETULA NANA - CYPERACEAE - ARTEMISIA - RUMEX - HIPPOPHAË Local Assemblage Zone.

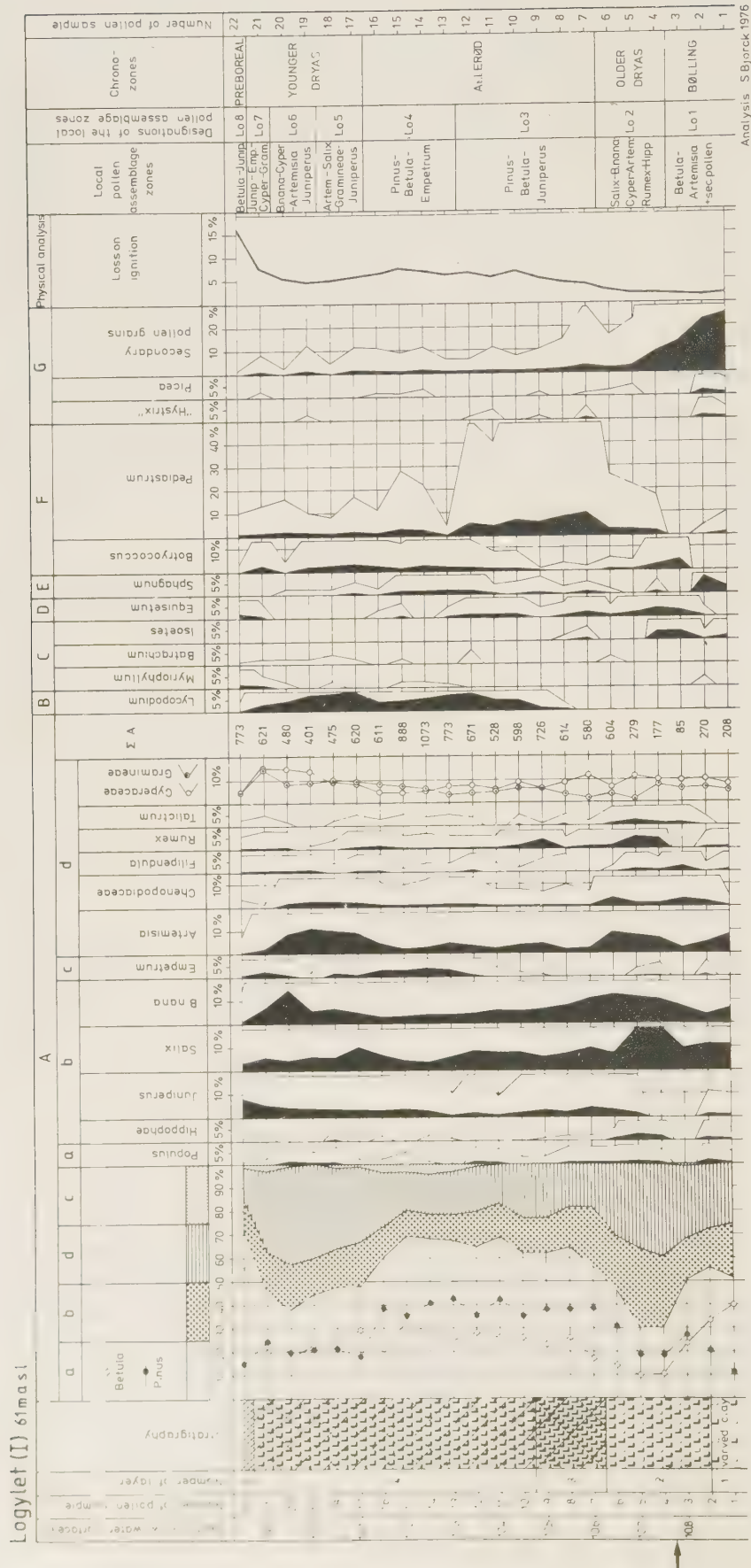


Fig. 15. The first pollen analysed core from Lake Logylet.

- Lo3 1062.5 - 1032.5 cm and 1030 - 1004 cm. This zone is characterized by high values of tree pollen, with Pinus pollen as the dominant pollen type (between 30 and 45 %). The Juniperus pollen values increase compared to zone Lo2.
This zone is named the PINUS - BETULA undiff. - JUNIPERUS Local Assemblage Zone.
- Lo4 1032.5 - 1012.5 cm and 1004 - 993.5 cm. The only significant difference between this zone and zone Lo3 is the increasing values of Empetrum pollen.
The zone is named the PINUS - BETULA undiff. - EMPETRUM Local Assemblage Zone.
- Lo5 1012.5 - 1002.5 cm and 993.5 - 985 cm. Characterized by abundant herb pollen. Artemisia and Gramineae pollen reach values of more than 10 %. Among the shrub pollen types Salix and Juniperus pollen are dominant. The tree pollen values as well as the dwarf-shrub pollen values are low.
This zone is named the ARTEMISIA - SALIX - GRAMINEAE - JUNIPERUS Local Assemblage Zone.
- Lo6 1002.5 - 992.5 cm. This zone is characterized by increasing frequencies of B. nana and Cyperaceae pollen compared to zone Lo5.
The zone is named the BETULA NANA - CYPERACEAE - ARTEMISIA - JUNIPERUS Local Assemblage Zone.
- Lo7 992.5 - 987.5 cm. Compared to zone Lo6 this zone is characterized by increasing values of Juniperus and Empetrum pollen as well as by decreasing values of B. nana and Artemisia pollen. The tree pollen values are still low.
This zone is named the JUNIPERUS - EMPETRUM - CYPERACEAE Local Assemblage Zone.
- Lo8 987.5 - 985 cm. Characterized by rapidly increasing values of Betula undiff. pollen compared to zone Lo7. Juniperus pollen reaches its highest frequency, while Salix, B. nana, Artemisia, Chenopodiaceae and Cyperaceae pollen

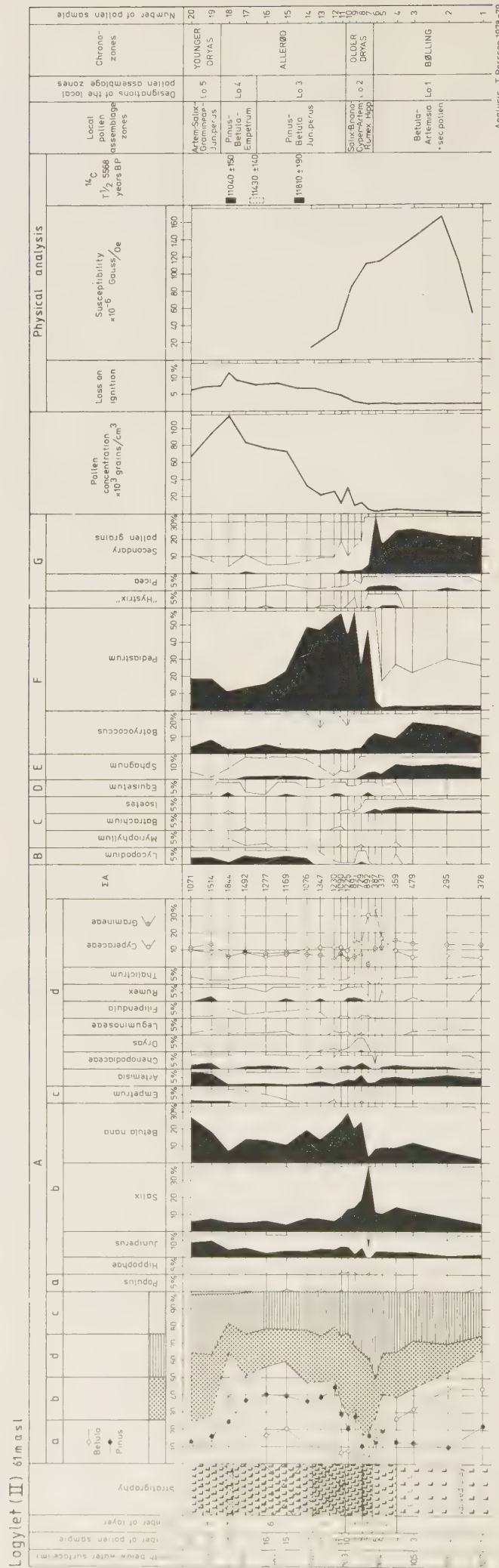


Fig. 16. The last pollen analysed core from Lake Logylet.

reach their lowest value within this zone.

The zone is named the BETULA undiff. - JUNIPERUS Local Assemblage Zone.

5.3.4. Radiocarbon analyses

Out of four levels sampled from Logylet, three were possible to radiocarbon date. The undateable level is the boundary between zones Lo1 and Lo2. The other three levels are shown in Fig. 16. A radiocarbon age of $11,810 \pm 190$ B.P. (Lu-1597) was obtained for the middle part of zone Lo3 (10.18 - 10.15 m). As has been pointed out above, the boundary between zones Lo3 and Lo4 has been radiocarbon dated from a third core, but this date has been related to the diagram in Fig. 16, which means that this boundary is supposed to have a radiocarbon age of $11,430 \pm 140$ B.P. (Lu-1444) and comprises 4 cm of the dated core. The boundary between zones Lo4 and Lo5 was radiocarbon dated to $11,040 \pm 150$ B.P. (Lu-1598) and comprises the sediments between 9.98 and 9.95 metres below the water surface.

5.3.5. Determination of the isolation level

The boundary between zones Lo1 and Lo2 is, apart from the pollen assemblage changes described in connection with the pollen stratigraphy, characterized by decreasing values of Sphagnum and Isoëtes spores, secondary pollen grains and "Hystrix". At the same level the values of Pediastrum colonies increase rapidly, while the values of loss on ignition increase just slightly. There is also a significant change in the character of the sediment as it changes in the lithologic composition as well as in colour. It is thus very clear that a very sudden event effects the sedimentation of the basin at this level. This event is interpreted as being the isolation of Logylet and it seems to be synchronous with the boundary between zones Lo1 and Lo2. The changes of the susceptibility values and the values of the magnetic content of the varved clay could possibly also be related to water level changes in the basin. However, the interpretation possibilities for these changes will be discussed later on.

5.4. Årsjön (4)

5.4.1. Description of the site

Årsjön is situated 1 km WSW of Backaryd and 19 km from the coast (Fig. 9). The water level of this rather large lake is now 56.3 m a.s.l. According to old documents it has been lowered to obtain arable land. Detailed studies of these documents, together with investigations of the man-made channel which now drains the lake, show that the original level of the lake was about 58 m a.s.l.

Årsjön is a part of the Vierydså river which flows into the very northern part of the lake and leaves it through the dug channel in the very south. The surrounding deposits are very varied. Apart from the north-western shore the lake is surrounded by silty and sandy deposits. The flat area between the lake and the commune of Backaryd probably represents a delta. The areas north, west and south of the lake more distant from the shore are characterized by rather marked slopes up to levels 85 to 90 m a.s.l. These areas consist of rather boulder-rich tills and bed-rock, except for the narrow valley of Vierydsån, where silts and sands dominate in the south and gravel and sand in the north. Pinetrees are abundant in the area east of Årsjön. This is probably due to the very dry soils dominating this area.

5.4.2. Sediment stratigraphy

Three preliminary cores with the Russian sampler were taken in 1977. The main sampling point is situated 400 m SSW of the inflow of Vierydsån and 50 m from the shore where the water depth is 3.0 m. The sediments down to 7.25 m were not investigated.

725 - 755 cm	Layer 4. Fine detritus gyttja, brownish-black. Composition: Ld 4. Lower boundary diffuse.
755 - 777 cm	Layer 3. Muddy silty clay, light green-grey. Composition: As 3, Ag 1, Ld 0.5, Th+. Lower boundary diffuse. Plant remains between 762 and 777 cm.

- 777 - 813 cm Layer 2. Clayey silty gyttja. Dark green-grey.
Composition: As 2, Ag 1, Ld 1, Th+. Lower
boundary sharp.
Plant remains between 777 and 780 cm and 792-
810 cm. Greenish black laminations, probably
sulphite lamination.
- 813 - 825 cm Layer 1. Silty clay, blackish grey.
Composition: As 2, Ag 2. Greenish black lamina-
tions, probably sulphite lamination.

From the sound produced when attempts were made to penetrate further, layer 1 is underlain by sands and gravels. These deposits can probably be related to the deglaciation of the lake. Layer 4 is not included in the diagram (Fig. 17).

5.4.3. Pollen stratigraphy

The pollen diagram from Årsjön is shown in Fig. 17. 14 levels have been analysed between 8.25 and 7.70 metres below the water surface. This profile has been divided into four local pollen assemblage zones (Å1-Å4).

Å1 824 - 815.5 cm. This is the lowest zone recorded in the sediments from Årsjön. It is characterized by abundant shrub and herb pollen. Salix and B. nana pollen attain values of 5 to 10 % and Hippophaë pollen is found only within this zone. Rumex pollen reaches a maximum value of 7 %, while the Artemisia pollen values stays around 5 %. Grass pollen is also rather common and reaches together values of about 15 %. Dryas pollen attain values of more than 1 %.

This zone is named the RUMEX - SALIX - BETULA NANA - ARTEMISIA - HIPPOPHAË Local Assemblage Zone.

Å2 815.5 - 792.5 cm. Characterized by a total dominance of tree pollen, with Pinus pollen attaining values of 50 to 80 %, while Betula undiff. pollen reaches a maximum value of 22 %. The only pollen types, excluding tree pollen, that do not have extremely low values are Salix, B. nana and grass pollen.

The zone is named the PINUS - BETULA undiff. Local

Assemblage Zone.

Å3 792.5 - 777.5 cm. The only significant change within this zone compared with zone Å2 is that the frequency of Betula undiff. pollen decreases while Empetrum pollen reaches a frequency of more than 3 %. Pinus pollen attains a maximum value of 37 %.

The zone is named the PINUS - EMPETRUM Local Assemblage Zone.

Å4 777.5 - 770 cm. This zone is characterized by the very sudden decrease of Pinus pollen values (from 81 to 21 %) and abundant herb and shrub pollen. Artemisia pollen reaches a maximum value of 9 % and grass pollen attains a frequency of 24 %. Salix pollen reaches values of 7 % and Juniperus pollen attains frequencies of 6 %.

Chenopodiaceae pollen reaches its highest value.

This zone is named the ARTEMISIA - SALIX - JUNIPERUS - GRAMINEAE - CYPERACEAE Local Assemblage Zone.

No radiocarbon analyses have been carried out from Årsjön.

5.4.4. Determination of the isolation level

Layer 1 in Årsjön is probably underlain by deposits associated with the deglaciation of the area. As the highest shore-line of the region is situated at least 5 metres above the original level of the lake (Ringberg, 1971), one would expect the presence of Baltic Ice Lake sediments in the profile analysed. Layer 1, however, does not have many similarities with this kind of sediment. It is rather coarse and although the amount of organic material is very low it is relatively rich in pollen grains and Pediastrum colonies. The amount of secondary pollen grains is too low to be associated with the early stage of the Baltic Ice Lake, at least in comparison with e.g. sites 2, 3, 5, 6 and 7 in this study. Another indication that layer 1 was not deposited in the Baltic Ice Lake is the presence of sulphite lamination. According to Ingmar (1973, p. 52) the change from an open bay to a closed lake causes a decrease in the amount of the oxygen in the water. This decrease most usually results in the introduction of H_2S in the bottom sediments.

From the above can be concluded that layer 1 is interpreted as being a sediment deposited in a lake already isolated from the Baltic Ice Lake.

5.5. Kroksjön (5)

5.5.1. Description of the site

Kroksjön is located 7.5 km north of Åryd and 12 km from the coast (Figs. 9, 18 and 19). It is situated 45.9 m a.s.l. and neither old documents nor the old economic map contains evidence that the lake has been lowered. However, field investigations of the threshold, located in the south-western part of the basin and consisting of bed-rock and till, clearly show that man has altered the water level of the lake. The magnitude of the alteration is hard to determine in this case, but it is certainly not less than 1 m. The original level of the lake is thus estimated to have been at least 47 m a.s.l.

The surrounding area is characterized by uneven topography. Immediately west of the lake a bed-rock ridge rises to more than 70 m a.s.l. Apart from bed-rock, boulder rich till is very common. Many small fissure valleys are situated in the vicinity of the lake. The whole area is very rich in lakes.

5.5.2. Sediment stratigraphy

Preliminary investigations with the Russian sampler showed the Late Weichselian in Kroksjön to be represented by several metres of sediments. For this reason the lake was of great interest, and in the winter of 1977 a 100 mm Livingstone core was taken. The sampling point is situated in the most western bay of the lake, between the island and the shore (Fig. 18). The water depth is 2.0 m and the sediments down to 4.45 metres below the water surface were not examined.

445 - 451.5 cm	Layer 7. Fine detritus gyttja, dark-brown. Composition: Ld 4. Lower boundary diffuse.
451.5 - 454.5 cm	Layer 6. Clayey gyttja, brown. Composition: Ld 2, As 2. Lower boundary sharp.

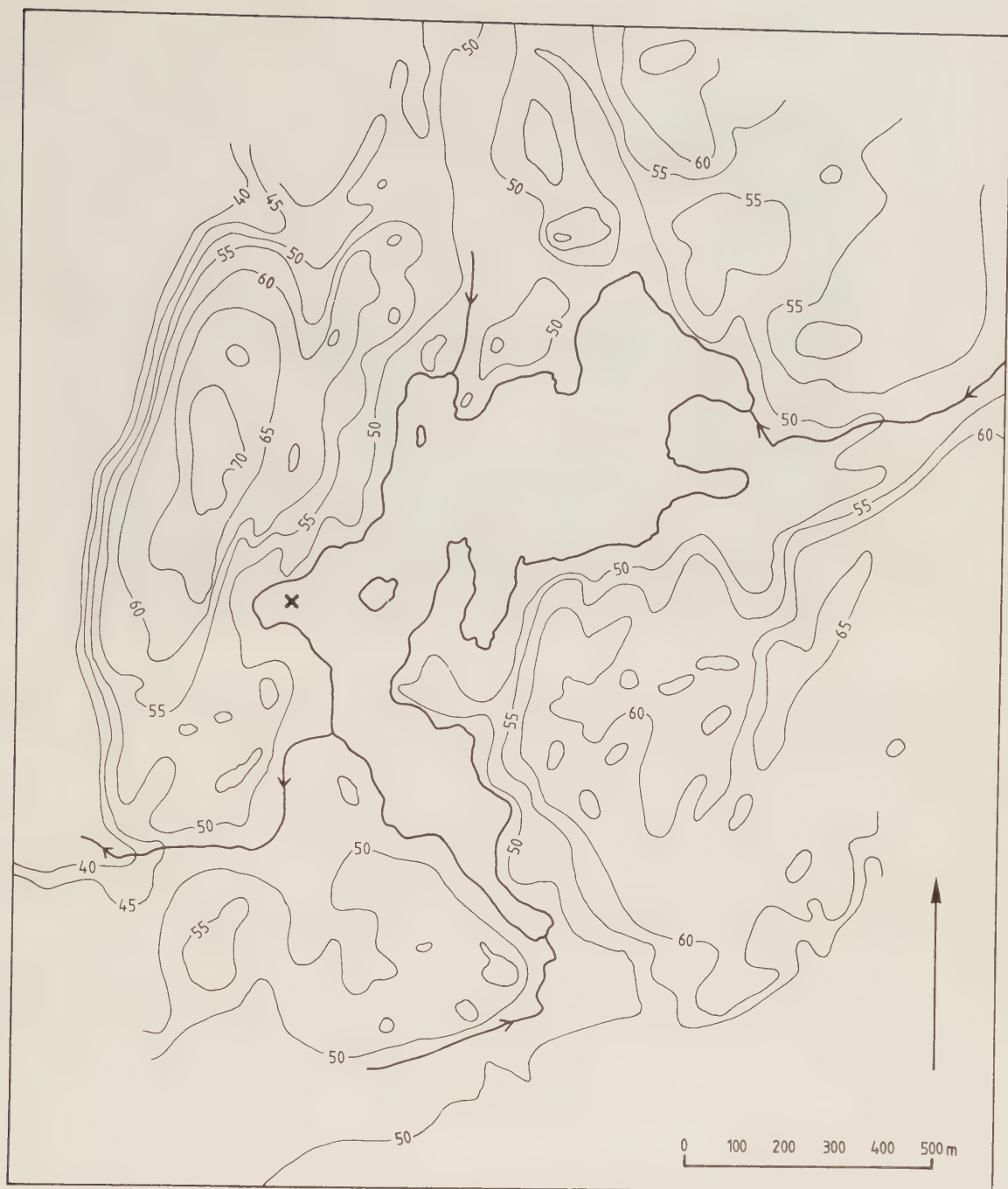


Fig. 18. The local topographic position of Lake Kroksjön. The cross marks the coring point.

- | | |
|------------------|--|
| 454.5 - 486.5 cm | Layer 5. Muddy clay, grey-brown.
Composition: As 4, Ld 0.5. Lower boundary sharp. |
| 486.5 - 494 cm | Layer 4. Clay gyttja, brown.
Composition: As 3, Ld 1. Lower boundary diffuse. |



Fig. 19. Lake Kroksjön seen from the shore just south of the coring point towards the northeast.

494	-	506	cm	Layer 3. Slightly muddy clay, grey-brown. Composition: As 4, Ld 0.5. Lower boundary sharp.
506	-	519	cm	Layer 2. Clay, brownish grey. Composition: As 4. Lower boundary gradual.
519	-	889	cm	Layer 1. Varved clay, red winter laminae and grey-brown summer laminae. Composition: As 2, Ag 2.

The varved clay was counted from cores taken with the Russian sampler and altogether 268 varves were measured. The varves between 542 and 519 cm were impossible to count, but the number of varves within these 23 centimetres was estimated to about 50. The varve diagram is shown in Fig. 20 and the time scale is related to the local time scale established by Ringberg (1979). One of the main characters of the varved clay in Blekinge is the presence of the so-called diffuse varves (Ringberg, 1971, 1979). These varves were also found in Kroksjön, which made the correlation with the local varve chronology more reliable. The diffuse varves in Kroksjön start at varve year + 104 as transitional varves. After about 20 transitional varves the varves are very diffuse up to about varve year + 200.

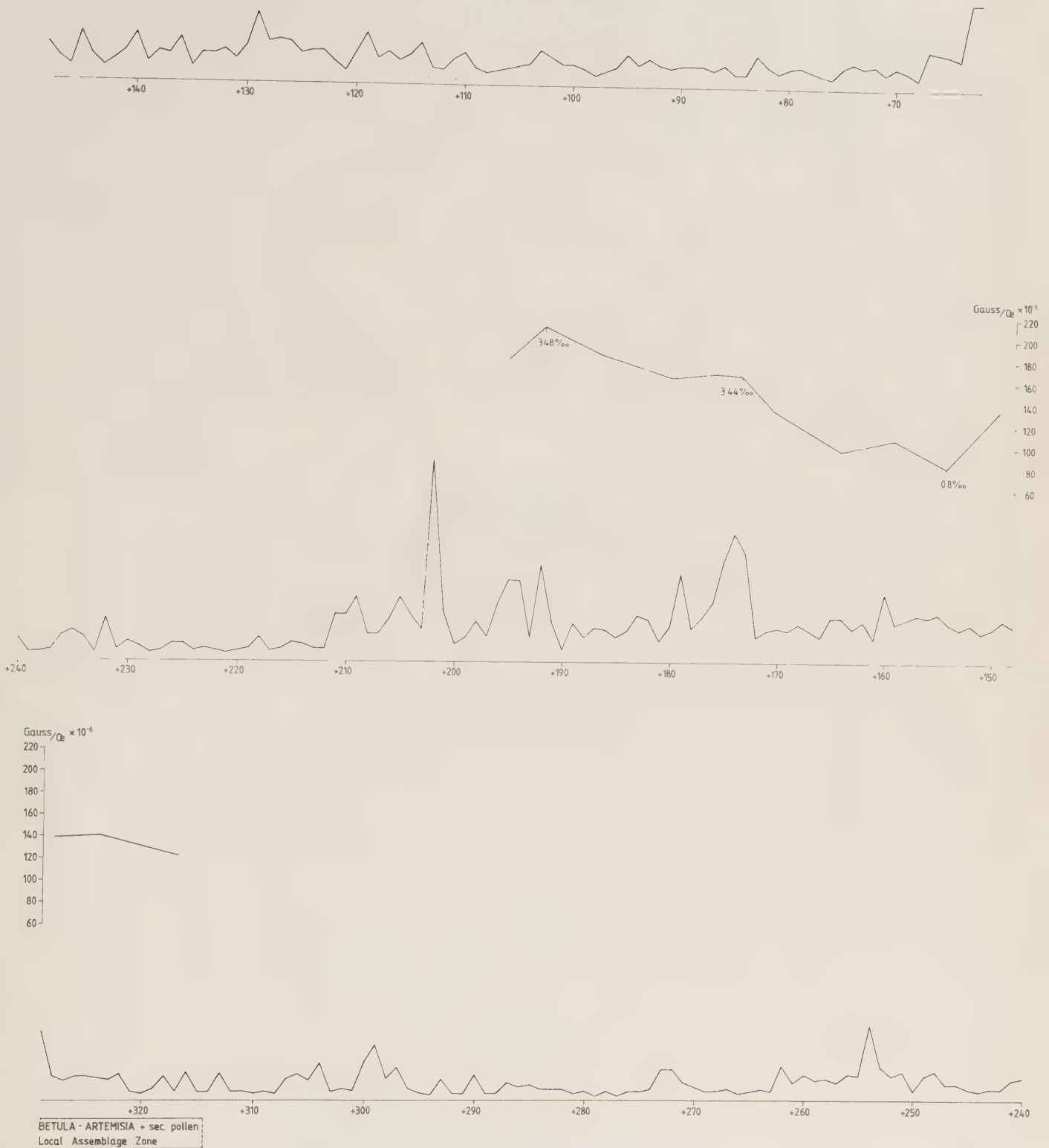
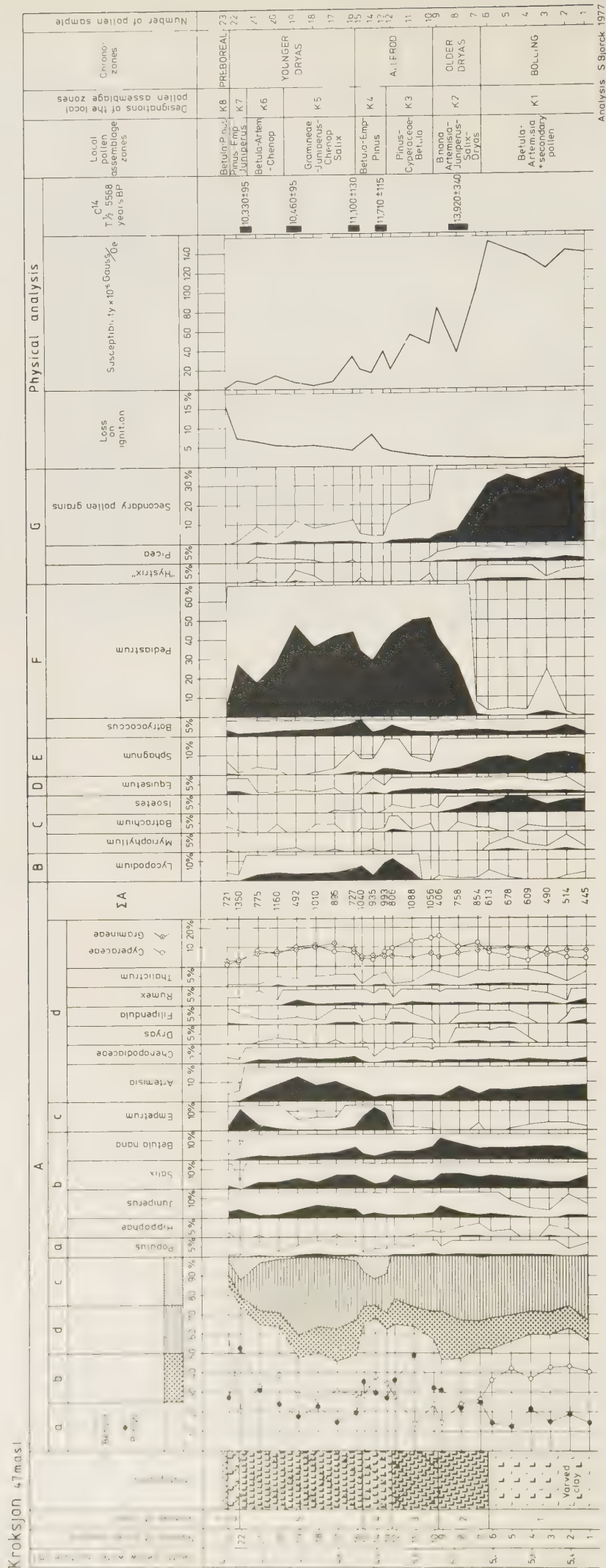


Fig. 20. Diagram of annual varves (thickness scale 2:5) from Lake Kroksjön, related to Ringberg's local varve chronology, the pollen zonation, values of the magnetic susceptibility and the magnetite values (in % of dry weight).



X-ray diffraction of the clay shows that it is composed of the same minerals as the varved clay at Logylet (site 3). The magnetic susceptibility of parts of the varved clay have been investigated and the values are related to the varve diagram as well as the values of magnetite. It is also clear from the varve and pollen diagrams that the youngest varves measured correspond to the lowermost part of the Local Assemblage Zone K1.

5.5.3. Pollen stratigraphy

The pollen analysed section from Kroksjön comprises the sediments between 5.45 and 4.52 metres below the water surface. Within this section, 23 levels have been analysed from this section and the pollen diagram (Fig. 21) has been divided into eight local pollen assemblage zones (K1-K8).

- K1 545 - 518.5 cm. This zone, the lowest recorded, is characterized by high frequencies of Betula undiff. pollen, reaching a value of about 40 %. Artemisia pollen reaches values between 6 and 8 %. Secondary pollen grains reach values of 30 %, or more.
The zone is named the BETULA undiff. - ARTEMISIA + secondary pollen grains Local Assemblage Zone.
- K2 518.5 - 506 cm. Characterized by increasing values of herb and shrub pollen and decreasing values of Betula undiff. pollen. B. nana pollen attains a frequency of 11 % and Salix pollen reaches values of 6 %, or more. The values of Juniperus and Artemisia pollen are rather high, and Dryas pollen reaches a frequency of 1 %, or more. The values of Pinus pollen increase slowly, while the frequency of secondary pollen grains decrease rapidly.
This zone is named the BETULA NANA - ARTEMISIA - JUNIPERUS - SALIX - DRYAS Local Assemblage Zone.
- K3 506 - 494 cm. Characterized by abundant tree pollen with Pinus pollen dominant, reaching values between 32 and 49 %. Among herb pollen Cyperaceae pollen is dominant, reaching frequencies between 10 and 15 %. The values of shrub pollen are low.
The zone is named the PINUS - CYPERACEAE - BETULA undiff. Local Assemblage Zone.

- K4 494 - 486 cm. Principally characterized by a sudden increase of the values of Empetrum pollen, reaching a maximum frequency of 12 %. The Betula undiff. pollen reaches frequencies between 29 and 39 %. The values of Pinus pollen decrease, but still remain rather high. With the exception of these three pollen types, the values of other pollen types are low.
This zone is named the BETULA undiff. - EMPETRUM - PINUS Local Assemblage Zone.
- K5 486 - 467.5 cm. Characterized by abundant herb pollen with Artemisia and Gramineae pollen dominant, reaching values of about 10 %. The frequency of shrub pollen also increases. Salix and Juniperus pollen reach values of 5 %, or more. The values of Chenopodiaceae and Rumex pollen are comparatively high. The tree pollen frequency is about the same as in zone K2 and the frequency of dwarf-shrub pollen is very low. The zone is named the ARTEMISIA - GRAMINEAE - JUNIPERUS - CHENOPODIACEAE - SALIX Local Assemblage Zone.
- K6 467.5 - 457.5 cm. Characterized by increasing values of tree pollen with Betula undiff. pollen dominant, reaching values of about 35 %. The values of herb pollen are still rather high, while the frequency of shrub pollen is low. This zone is named the BETULA undiff. - ARTEMISIA - CHENOPODIACEAE Local Assemblage Zone.
- K7 457.5 - 453.5 cm. Characterized by abundant Pinus pollen, reaching a value of 53 %. The frequency of Empetrum pollen is higher than 11 % and Juniperus pollen also attains a high value. The value of Betula undiff. pollen is low. The zone is named the PINUS - EMPETRUM - JUNIPERUS Local Assemblage Zone.
- K8 453.5 - 452 cm. This zone, the upper-most recorded in Kroksjön, is characterized by abundant Betula undiff. pollen, attaining a value of 58 %. No other pollen type is significant in this zone.
The zone is named the BETULA undiff. Local Assemblage Zone.

5.5.4. Radiocarbon analyses

Out of eight levels samples from Kroksjön, five were possible to radiocarbon date. The levels with an organic content too low for ^{14}C dating were 5.40 to 5.30, 5.20 to 5.15 and 5.08 to 5.03 metres below the water surface. The lowermost dateable level was situated between 5.15 and 5.10 m, which corresponds to zone K2 and layer 2. The radiocarbon age of this sample was $13,920 \pm 340$ B.P. (Lu-1477). The sediments between 4.94 and 4.91 m were radiocarbon dated to $11,710 \pm 115$ B.P. (Lu-1479). This level represents the beginning of zone K4 and layer 4. The boundary between zones K4 and K5 and layers 4 and 5 (4.87 - 4.84 m) was radiocarbon dated to $11,100 \pm 130$ B.P. (Lu-1480). A radiocarbon age of $10,460 \pm 95$ B.P. (Lu-1481) was obtained from the level 4.72 to 4.68 m, which marks the end of zone K5. The uppermost radiocarbon dated level is situated between 4.59 and 4.56 metres below the water surface and corresponds to the transition between zones K6 and K7. The radiocarbon age was $10,330 \pm 95$ B.P. (Lu-1482). These radiocarbon ages will be discussed in Chapter 6.

5.5.5. Diatom stratigraphy

Samples 6 to 11 have been analysed in respect of the composition of diatoms. In samples 6 to 8 altogether 7 diatoms were counted, with the exception of some remains of dissolved valves, while between 180 and 381 have been counted in samples 9 to 11. The species have been halobian grouped according to Kolbe (1927), whose system was re-defined by Hustedt (1957). This grouping shows that all analysed diatoms, with some very few exceptions, are oligohalobous, which strongly suggests a fresh water environment.

5.5.6. Determination of the isolation level

Sediments like the varved clay of layer 1 are usually associated with deposition in the Baltic Ice Lake in Blekinge. This is further supported by the possibility of correlating the varve diagram, or at least parts of it, with the local varve chronology. The clay of layer 2 also appears very much like a Baltic Ice Lake clay, but as can be seen in the diagram (Fig. 21), marked changes occur between samples 7 and 8 within layer 2. The frequency of Pediastrum colonies increases by almost 400 %, while the values of Isoëtes and Sphagnum

spores, "Hystrix", secondary pollen grains and the magnetic susceptibility decrease very strongly. The changes are hardly detectable in the lithostratigraphy as the increase of loss on ignition is extremely low. But most likely, sample 8 is the first level analysed after the isolation in the core from Kroksjön. This isolation level corresponds to zone K2 and a radiocarbon age of about 14,000 B.P. This extremely high age will be discussed in Chapter 6.

5.6. Dönhultagyl (6)

5.6.1. Description of the site

This lake is situated 2.5 km NNE of Bräkne-Hoby and 9 km from the coast (Fig. 9). The water level of the lake varies between 42 and 43 m a.s.l. according to two different topographic maps. Studies of old documents show that the outflow of the lake has been moved from the northwestern to the southern part of the lake. From the appearance of the two outflows, the lake has been lowered 1.5 to 2 metres. The original level of the lake is estimated at 44.5 m a.s.l.

Dönhultagyl lies just east of the river valley of Bräkneån. It is surrounded by slightly uneven ground dominated by till and bed-rock and minor basins filled with peat. The highest levels reach 50 to 55 m a.s.l. In the river valley, 1 to 2 km west of the lake, sorted sediments dominate. The western part of the shore consists of a birch-alder carr.

5.6.2. Sediment stratigraphy

Cores were taken from the schwing moore between the carr and the open water at the very western part of the lake in 1974. The Russian sampler was used. The sediments down to 1.5 m have not been investigated.

150 - 175 cm	Layer 7. Fine detritus gyttja, brown. Composition: Ld 4. Lower boundary sharp.
175 - 178 cm	Layer 6. Clay gyttja, brown. Composition: As 3, Ld 1. Lower boundary diffuse.

178 - 183 cm	Layer 5. Clay gyttja, dark-brown. Composition: As 2, Ld 2. Lower boundary diffuse.
183 - 188 cm	Layer 4. Clay gyttja, brown. Composition: As 3, Ld 1. Lower boundary diffuse.
188 - 213 cm	Layer 3. Clay gyttja, light-brown. Composition: As 3, Ld 1. Lower boundary sharp.
213 - 223 cm	Layer 2. Muddy clay, grey. Composition: As 4, Ld 0.5. Lower boundary diffuse.
223 - 250 cm	Layer 1. Clay, grey. Composition: As 4.

The clay of layer 1 appears very similar to the unvarved Baltic Ice Lake clay found overlying varved clay at the coast.

5.6.3. Pollen stratigraphy

The pollen diagram, representing the sediments from 1.71 to 2.45 metres below the schwing moore surface (more or less the same as the water level), is shown in Fig. 22.

All samples from this profile have been prepared by the HF-method without any $ZnCl_2$ treatment. Some microfossils have not been included in the diagram as e.g. Dryas, Thalictrum and Equisetum. This is due to identification problems and in the case of Equisetum the reason was the presence of a microfossil looking very much like Equisetum spores. Thus they were very difficult to separate.

13 levels have been analysed and the diagram is divided into six local pollen assemblage zones (D1-D6).

- D1 245 - 237.5 cm. The abundance of shrub pollen together with high values of Betula undiff. pollen (27 to 32 %) are characteristic for this zone. B. nana pollen attains its maximum value of 18 % and Salix pollen reaches a value of 10 %. Secondary pollen grains (mainly Corylus and Alnus pollen) attain frequencies between 20 and 37 %. The zone is named the BETULA NANA - BETULA undiff. - SALIX + secondary pollen grains Local Assemblage Zone.

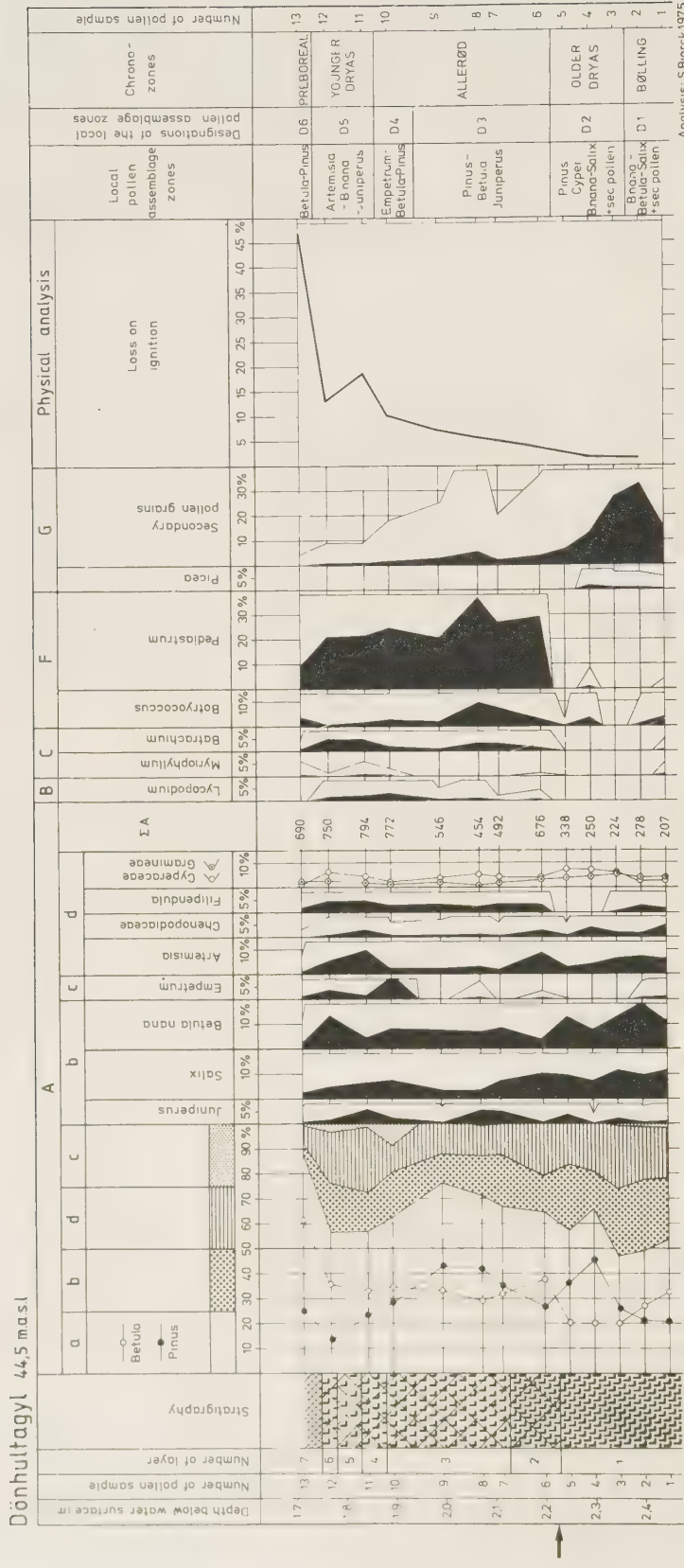


Fig. 22. The pollen diagram from Lake Dönhultagyl.

- D2 237.5 - 222.5 cm. Characterized by a decrease of the values of Betula undiff. pollen and an increase of the frequencies of Pinus pollen compared with zone D1. Cyperaceae pollen attains values of more than 7 %. Secondary pollen grains reach high values. This zone is named the PINUS - CYPERACEAE - BETULA NANA - SALIX + secondary pollen grains Local Assemblage Zone.
- D3 222.5 - 195 cm. Characterized by high values of Pinus and Betula undiff. pollen. Together they reach values between 65 and 75 %. The herb pollen frequency decreases while Juniperus pollen attains values of about 5 %. The zone is named the PINUS - BETULA undiff. - JUNIPERUS Local Assemblage Zone.
- D4 195 - 187.75 cm. Characterized by high values of dwarf-shrub pollen with Empetrum pollen reaching frequencies of 9 %. Pinus pollen attains values of 25 % or more and Betula undiff. pollen reaches values of about 35 %. The frequencies of herb and shrub pollen are about the same as in zone D3. This zone is named the EMPETRUM - BETULA undiff. - PINUS Local Assemblage Zone.
- D5 187.75 - 174.5 cm. Characterized by rather high frequencies of herb pollen with Artemisia pollen dominant with values of 5 % or more. Shrub pollen frequencies are also high with Juniperus pollen reaching values of more than 5 % and B. nana pollen attaining frequencies of 10 % or more. The zone is named the ARTEMISIA - BETULA NANA - JUNIPERUS Local Assemblage Zone.
- D6 174.5 - 171 cm. Characterized by abundant tree pollen. Betula undiff. pollen reaches a value of more than 60 % and Pinus pollen attains a value of 25 %. All pollen types, except these two, have lower values than in zone D5. This zone is named the BETULA undiff. - PINUS Local Assemblage Zone.

5.6.4. Determination of the isolation level

Layer 1 appears to be an ice lake clay while layer 2 is characterized by a higher organic content than is common for such a sediment. It is also obvious from the pollen diagram (Fig. 22) that a sudden change occurs between samples 5 and 6. Most notable is the increase of Pediastrum colonies and the decrease of secondary pollen grains. The Pinus pollen values decrease rapidly while the values of Botryococcus colonies increase.

Sample 6 is interpreted as being the first sample in the profile after the isolation. This means that the isolation of Dönhultagyl took place between zone D2 and D3.

5.7. Själbredan (7)

5.7.1. Description of the site

This small lake is located 9 km north of Åryd and 13.5 km from the coast (Fig. 9). It is situated 42 m a.s.l. and there are no signs of a lowering of the water level. Thus the original water level was situated about 42 m a.s.l. The surroundings of the lake are characterized by a very uneven topography dominated by till and bed-rock. The till is often very rich in boulders. The area is very rich in lakes.

5.7.2. Sediment stratigraphy

In the winter of 1978 a core was taken with a Livingstone piston corer. The main reason for this field work was for teaching purposes, but as the level of the lake fills a small gap in this study further interest was shown in the core. The stratigraphy (the figures given below are the depth below the water surface) is as follows.

557 - 581 cm	Layer 3. Clay gyttja, brown. Composition: As 3, Ld 1. Lower boundary sharp.
581 - 601 cm	Layer 2. Slightly muddy clay, grey. Composition: As 4, Ld+. Lower boundary gradual.
601 - 621 cm	Layer 3. Clay, grey. Composition: As 4.

5.7.3. Radiocarbon analyses

One sample was taken for radiocarbon dating from the core in Sjalbredan, between 5.81 and 5.77 metres below the water surface. This corresponds to the very sharp boundary between layers 2 and 3. The radiocarbon age of the dated sample was 10.990 ± 135 B.P. (Lu-1554).

5.7.4. Determination of the isolation level

All sites, except Sjalbredan, have been at least pollen analysed before the isolation was determined. The main reason for this is that this level is often hard to determine by visual examination. However, in the case of Sjalbredan, the change between layers 2 and 3 appeared to be an isolation contact with a change from slightly muddy clay to clay gyttja. Although errors have been made in cases like this, it would strongly indicate that Sjalbredan was isolated between these layers. Layers 1 and 2 look very much like Baltic Ice Lake sediments and the suggested isolation contact in Sjalbredan is very similar to the isolation contact in e.g. Lilla sjön (site 8). If this visual interpretation is correct, Sjalbredan should have been isolated slightly earlier than 10,990 B.P.

5.8. Lilla sjön (8)

5.8.1. Description of the site

Lilla sjön is located 2 km east of Bräkne-Hoby and 6.5 km from the coast (Fig. 9). The water level of the lake is 38 m a.s.l. The outflow is situated in the south-western corner of the basin. There is no evidence, neither from old documents nor from the oldest economic maps, that the lake has been lowered. But unquestionably the threshold of the lake, consisting of till, has been altered, either by erosion or by digging, resulting in a lowering of level of about 1 m.

The original level of the lake is thus estimated at 39 m a.s.l. The surroundings of the basin are dominated by till, usually covering the bed-rock. North, east and south of the site the highest levels are between 50 and 55 m a.s.l., while west of the lake the ground slopes down to the river valley of Bräkneån, where the flat valley bottom consists of silt and clay.

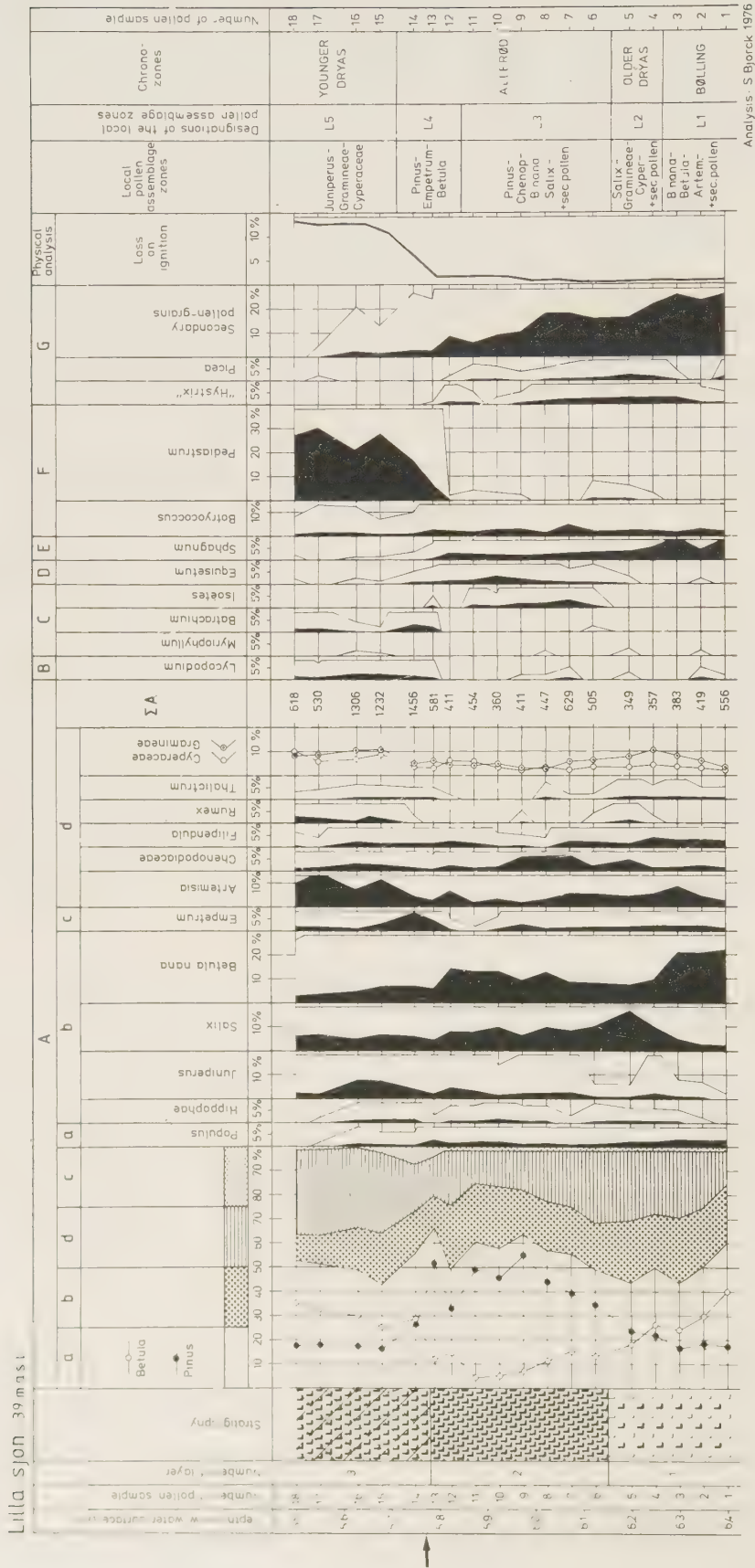


Fig. 23. The pollen diagram from Lake Lilla sjön.

5.8.2. Sediment stratigraphy

The stratigraphy of the lake has been described by Björck et al. (1978). Cores were taken with a Russian sampler during the winter of 1976 in the middle northern part of the basin, 60 metres from the shore. It was obvious from the beginning of coring in Lilla sjön that the Late Weichselian sequence was comparatively thick.

The water depth at the main sampling point is 3.3 m and the sequence between 3.3 and 5.1 has not been described.

510 - 533 cm	Layer 4. Clayey fine detritus gyttja, light greyish brown. Composition: Ld 3, As 1. Lower boundary diffuse.
533 - 578 cm	Layer 3. Clay gyttja, slightly sandy, light brownish grey. Composition: As 3, Ld 1, Th+. Lower boundary sharp. Plant remains between 5.45 and 5.55 m.
578 - 615 cm	Layer 2. Clay grey. Composition: As 4, Lower boundary gradual.
615 - 640 cm	Layer 1. Silty clay, light-grey. Composition: (As + Ag) 4.

No signs of lamination were found in layers 1 and 2. Layer 4 is not included in the pollen diagram (Fig. 23).

5.8.3. Pollen stratigraphy

The pollen diagram in Fig. 23 is a combination of the two diagrams published by Björck et al. (1978). This means that the pollen sums in Fig. 23 are an addition of the sums from the diagrams prepared by the two preparation methods. The profile analysed is 77 cm big, includes 18 samples and is divided into five local pollen assemblage zones (L1-L5).

- L1 640 - 627.5 cm. This is the lowest zone recorded in the sediments of Lilla sjön, and it is characterized by high values of Betula undiff. pollen (25 to 40 %) and B. nana pollen (more than 20 %). Artemisia pollen attains frequencies of 3 to 8 % and secondary pollen grains

(Corylus and Alnus pollen dominant) reach values of more than 25 %. This zone is named the BETULA NANA - BETULA undiff. - ARTEMISIA + secondary pollen grains Local Assemblage Zone.

- L2 627.5 - 616.25 cm. Characterized by abundant shrub and herb pollen with Salix and grass pollen dominant, reaching values of 10 % or more. The frequencies of Betula undiff. pollen as well as B. nana pollen decrease. Values for secondary pollen grains (15 to 20 %) remain high. The Rumex and Thalictrum pollen curves have small peaks within this zone.
The zone is named the SALIX - GRAMINEAE - CYPERACEAE + secondary pollen grains Local Assemblage Zone.
- L3 616.25 - 585 cm. Characterized by high values of tree pollen. Pinus pollen reaches values of 35 to 55 %. The shrub pollen frequencies are also high with B. nana pollen (8 to 14 %) and Salix pollen (6 to 10 %) dominant. The frequencies of secondary pollen grains are above 9 %. Chenopodiaceae pollen attains values of 5 %, or more, in a big section of the zone. Artemisia, Betula undiff. and grass pollen reach their lowest frequencies within this zone.
This zone is named the PINUS - CHENOPODIACEAE - BETULA NANA - SALIX + secondary pollen grains Local Assemblage Zone.
- L4 585 - 571.5 cm. This zone is characterized by high frequencies of Empetrum pollen reaching a value of more than 7 %. The values of Betula undiff. pollen increase and the Pinus pollen frequencies are still high. Herb and shrub pollen frequencies are relatively low. The zone is named the PINUS - EMPETRUM - BETULA undiff. Local Assemblage Zone.
- L5 571.5 - 550 cm. Characterized by abundant herb pollen with Artemisia (7 to 14 %) and grass pollen (15 % or more) dominant. Rumex pollen reaches values of 2 to 3 %. The Juniperus pollen curve reaches a peak of more than 7 %.

The Empetrum and tree pollen values decrease rapidly.
 This zone is named the ARTEMISIA - JUNIPERUS - GRAMINEAE
 - CYPERACEAE Local Assemblage Zone.

No radiocarbon analyses have been carried out from Lilla sjön.

5.8.4. Determination of the isolation level

The clay belonging to layers 1 and 2 is more or less a pure minerogenic sediment and the change in composition between layers 2 and 3 is very clear. The microfossil content (Fig. 23) also suggests a very significant change between samples 13 and 14. The changes in Pinus, Pediastrum, secondary pollen grains and loss on ignition curves are particularly conspicuous. This change is also noticeable in the Sphagnum, Isoëtes and "Hystrix" curves. This very marked boundary between layers 2 and 3 is believed to reflect the isolation of Lilla sjön from the Baltic Ice Lake and occurs consequently in zone L4.

5.9. Galtsjön (9)

5.9.1. Description of the site

Galtsjön is located 6 km from the coast right between Bräkne-Hoby and Ronneby (Figs. 9 and 24). The water level of the lake is situated 32 m a.s.l. Studies of old maps and documents have not provided any evidence of a lowering of the threshold by man. Nevertheless, field investigations at the threshold area, situated in the very western part of the area, have shown that the bed-rock threshold probably has been blasted. The size of the lowering is estimated to about 1 m. This means that the original level of the lake should have been about 33 m a.s.l.

The lake is surrounded by a rather hilly area consisting of bed-rock and boulder rich till. These areas reach altitudes of 50 to 55 m a.s.l. Two very pronounced fissure valleys are located west of Galtsjön. The nearest has a direction of N-S while the valley from Nässjön has a direction of NNE-SSW. Another valley is located east of the lake with the direction of NNW-SSE. In these valleys clay dominate. This, for many reasons, very interesting bed-rock dependent plateau between Bräkne-Hoby and Ronneby has been described



Fig. 24. Coring in the winter of 1977 at Lake Galtsjön. The lake is seen from the west.

in detail by Gustavsson (1977).

5.9.2. Sediment stratigraphy

After preliminary investigations with the Russian sampler coring with the 100 mm Livingstone corer was carried out in the eastern part of the western bay of the lake. This was done in 1977. The water depth is 5.0 m at the sampling point and the sediments between 5.0 and 7.28 m were not examined.

728 - 750 cm	Layer 7. Fine detritus gyttja, brownish black. Composition: Ld 4. Lower boundary diffuse.
750 - 758 cm	Layer 6. Slightly clayey fine detritus gyttja, brown. Composition: Ld 3, As 1. Lower boundary diffuse.
758 - 761 cm	Layer 5. Clayey gyttja, green-brown. Composition: Ld 2, As 2. Lower boundary sharp.
761 - 765 cm	Layer 4. Clay gyttja, light greenish grey. Composition: As 3, Ld 1. Lower boundary sharp.

- 765 - 777 cm Layer 3. Clayey gyttja, grey-brown.
Composition: Ld 2, As 2, Th+. Lower boundary diffuse. Plant remains between 7.73 and 7.76 m.
- 777 - 797 cm Layer 2. Muddy clay, light greenish grey.
Composition: As 3, Ld 1. Lower boundary sharp.
- 797 - 809 cm Layer 1. Clay, light-grey.
Composition: As 4.

5.9.3. Pollen stratigraphy

The pollen diagram is shown in Fig. 25. It comprises the sequence between 8.09 and 7.49 m and within these 60 cm 18 levels have been analysed. The profile has been divided into seven local pollen assemblage zones (G1-G7).

- G1 809 - 801.5 cm. This is the lowest recorded zone from Galtsjön. It is characterized by high values of Betula undiff. pollen (24 to 34 %) and by high frequencies of shrub pollen. The values of Salix pollen stay around 10 % and the frequency of B. nana pollen varies between 8 and 14 %. The values of Hippophaë pollen exceed 1 %. Filipendula pollen values reach a maximum of about 3 %. The frequency of secondary pollen grains (mainly Corylus, Alnus and Quercus pollen) is 10 %, or more. The zone is named the BETULA undiff. - SALIX - BETULA NANA - HIPPOPHAË - FILIPENDULA + secondary pollen grains Local Assemblage Zone.
- G2 801.5 - 794.5 cm. Mainly characterized by a sudden increase in the values of Pinus pollen (between 34 and 42 %) together with increasing frequencies of Empetrum (3 to 4 %) and Cyperaceae pollen (more than 13 %). The frequencies of Betula undiff. and shrub pollen decrease considerably, while the values of herb pollen are about the same as in zone G1. This zone is named the PINUS - CYPERACEAE - EMPETRUM Local Assemblage Zone.
- G3 794.5 - 777.5 cm. This zone is characterized by abundant herb pollen with Artemisia (between 7 and 16 %) and grass

pollen (20 % or more) dominant. The frequency of Cyperaceae pollen is 10 %, or more. Among shrub pollen Juniperus is dominant reaching values of 5 %, or more. The tree pollen values are rather low.

The zone is named the ARTEMISIA - CYPERACEAE - GRAMINEAE - JUNIPERUS Local Assemblage Zone.

- G4 777.5 - 767.5 cm. Characterized by increasing values of tree pollen. Pinus and Betula undiff. pollen both attain values of about 30 %. The frequency of herb pollen decreases with the exception of the grass pollen frequencies which together reach values of 16 %, or more. The values of shrub and dwarf-shrub pollen are low. The zone is named the BETULA undiff. - PINUS - CYPERACEAE - GRAMINEAE Local Assemblage Zone.

- G5 767.5 - 760 cm. This zone is characterized by abundant tree and shrub pollen with Pinus pollen dominant attaining values of 32 %, or more. Salix pollen reaches values between 4 and 8 % and Juniperus pollen attains frequencies of about 5 %. Herb pollen values decrease while Empetrum pollen is 2 %, or more. Hippophaë pollen is present.

This zone is named the PINUS - SALIX - JUNIPERUS - EMPETRUM Local Assemblage Zone.

- G6 760 - 752 cm. Characterized by abundant Betula undiff. pollen reaching values between 46 and 68 %. The values of herb pollen are extremely low. The only pollen type, apart from tree pollen, exceeding values of 5 % is Gramineae pollen.

The zone is named the BETULA undiff. Local Assemblage Zone.

- G7 752 - 749 cm. Characterized by a total dominance of tree pollen. Together Pinus and Betula undiff. pollen reach a value of more than 88 %.

This zone is named the PINUS - BETULA undiff. Local Assemblage Zone.

5.9.4. Radiocarbon analyses

Four samples have been radiocarbon dated from the analysed core from Galtsjön. The lowest radiocarbon analysed level is between 7.94 and 7.99 metres below water level, which corresponds to the boundary between zone G2 and G3. The ^{14}C -age of this sample is $11,000 \pm 110$ B.P. (Lu-1423). The middle part of zone G5, 7.62 to 7.65 m, and the boundary between zone G5 and G6, 7.59 to 7.61 m, have also been dated. The lower sequence was radiocarbon dated to $10,050 \pm 100$ B.P. (Lu-1424) while the uppermost had a radiocarbon age of $10,020 \pm 120$ B.P. (Lu-1425).

5.9.5. Determination of the isolation level

As seen in Fig. 25 the clay in layer 1 is very rich in Lycopodium, Isoëtes, Equisetum and Sphagnum spores in its lower part. The values of "Hystrix" and secondary pollen grains are also rather high, while the frequencies of colonies of Pediastrum and Botryococcus are low. The magnetic susceptibility value is high in sample 1 but decreases in samples 2, 3 and 4 followed by an increase in sample 5. From the spore and algae curves the major changes occur between samples 2 and 3 and between samples 3 and 4. Some striking changes also occur between samples 4 and 5.

It may be concluded that the change between samples 3 and 4 appears more like an isolation development than the other two alternatives. This is also supported by the increased value of loss on ignition in sample 4. Even if one of the other alternatives had been chosen, the date of the isolation would have been broadly the same. It is quite clear that the isolation occurred in zone G2 and probably in the latter part of it. As the boundary between zones G2 and G3 is dated to 11,000 B.P., the isolation should be slightly older.

5.10. Halsjön I (10a)

5.10.1. Description of the site

This lake is located 2 km southeast of Kallinge and 7 km from the coast (Figs. 9, 26 and 27). It is situated 29.4 m a.s.l. and no evidence has been found, neither in old documents nor from the old

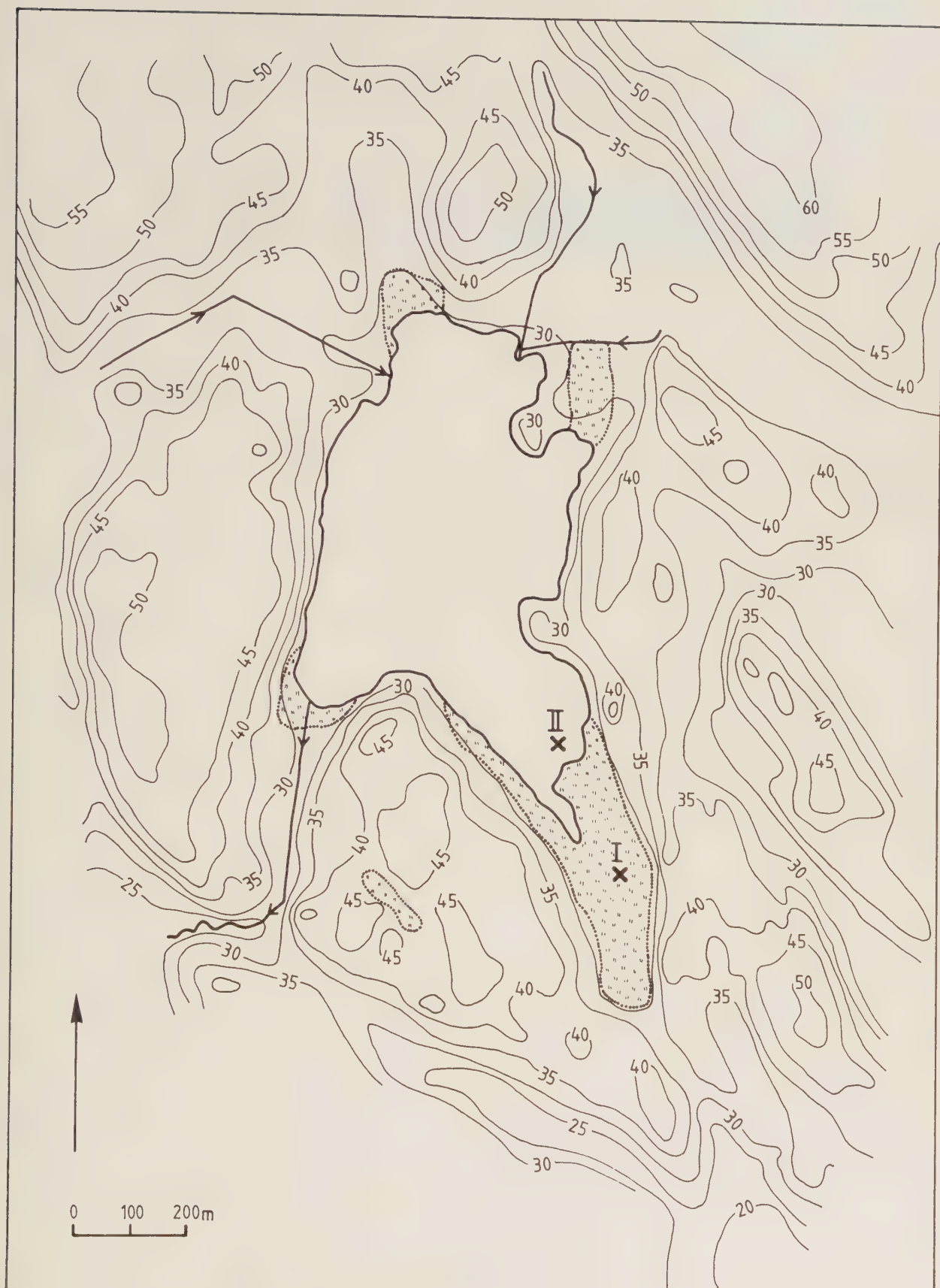


Fig. 26. The local topographic position of Lake Halsjön. The two crosses mark the two coring points.

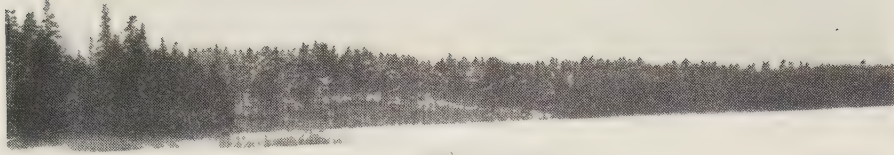


Fig. 27. Lake Halsjön seen from coring point II towards the northwest in the winter of 1978.

economic map, that the lake has been lowered. The outflow of the basin is situated in the southwestern part of the lake and the threshold lies a couple of hundred metres south of the outflow. It consists of bed-rock and it appears that the outflow channel has been cleaned of the till covering the bed-rock. This work may have lowered the lake about 0.5 m. Thus the original level is estimated to about 30 m a.s.l.

The area east of the lake consists mainly of till with some bed-rock exposures. North of the basin, silty and sandy deposits dominate between small hills of bed-rock and till. West and south of Halsjön clay is common between the bed-rock ridges. These ridges reach altitudes of about 55 m a.s.l., while the area north and east of the lake reaches altitudes of more than 60 m a.s.l.

5.10.2. Sediment stratigraphy

In the summer of 1976 corings were carried out on the mire in the southern part of the southeastern bay of Halsjön (Fig. 26). It was impossible to obtain a core with the 100 mm Livingstone piston corer, so instead two cores were taken with the Russian sampler.

The sediments between 0.0 and 3.4 metres below the mire surface were not classified.

340 - 415 cm	Layer 7. Fine detritus gyttja, green-brown. Composition: Ld 4. Lower boundary diffuse.
415 - 427 cm	Layer 6. Slightly clayey fine detritus gyttja, brown-black. Composition: Ld 3, As 1. Lower boundary sharp.
427 - 434 cm	Layer 5. Clay gyttja, brown. Composition: As 3, Ld 1. Lower boundary diffuse.
434 - 448 cm	Layer 4. Slightly muddy clay, light grey-green. Composition: As 4, Ld 0.5. Lower boundary diffuse.
448 - 457 cm	Layer 3. Muddy clay, grey-green. Composition: As 3, Ld 1. Lower boundary diffuse.
457 - 475 cm	Layer 2. Slightly muddy clay, grey-green. Composition: As 4, Ld 0.5. Lower boundary diffuse.
475 - 540 cm	Layer 1. Clay, light-grey. Composition: As 4, Th+. Plant remains at 4.80 m. A lamina of sand between 5.06 and 5.05 m.

No signs of lamination have been found in layer 1.

5.10.3. Pollen stratigraphy

The pollen analysed profile (Fig. 28) comprises the sediments between 5.20 and 4.20 metres below the mire surface. Within this metre, 20 levels have been analysed and the diagram has been divided into six local pollen assemblage zones (HI1-HI6).

- HI1 520 - 505 cm. This zone is characterized by abundant Pinus pollen, reaching values of about 55 %. B. nana pollen attains frequencies of about 5 % and secondary pollen grains reach values of more than 10 %. The Betula undiff. pollen values are low.
This zone is named the PINUS - BETULA NANA + secondary pollen grains Local Assemblage Zone.
- HI2 505 - 482.5 cm. Characterized by comparatively high values of Empetrum (about 5 %) and Pinus pollen (between

Halsjön I 30 masl.

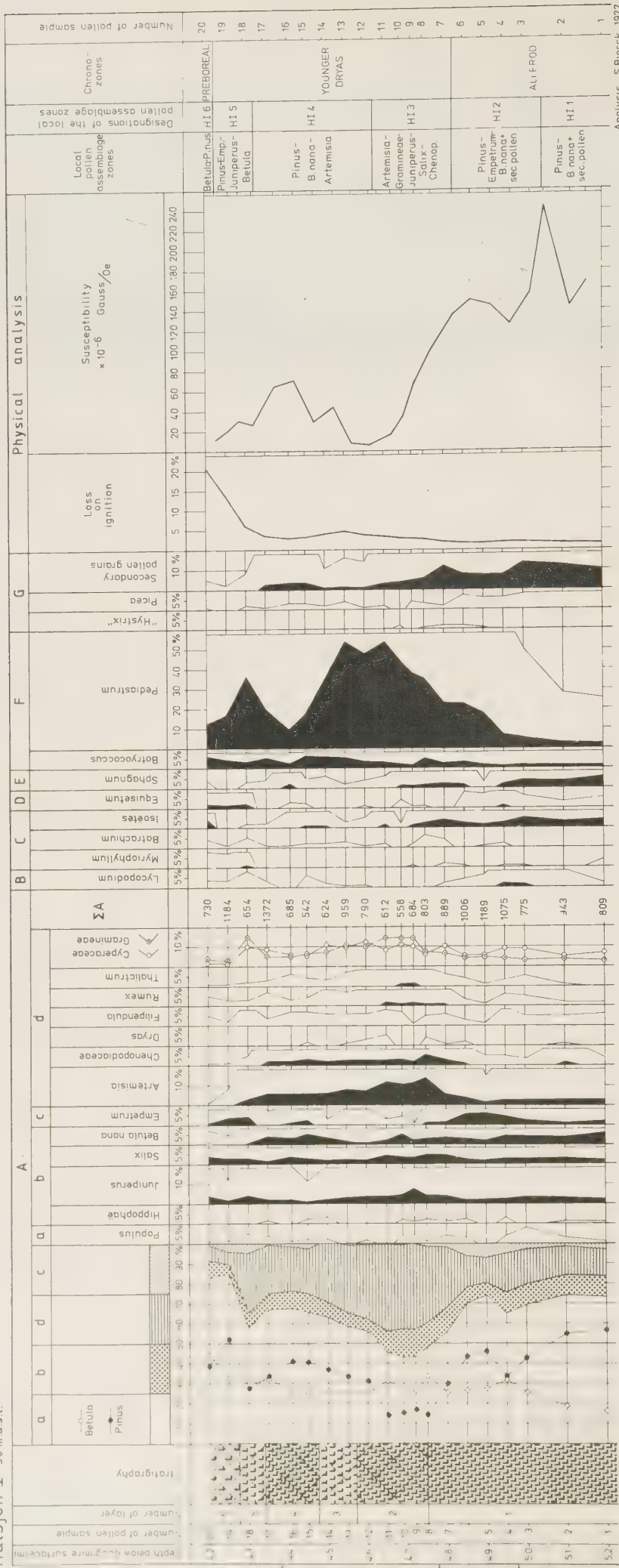


Fig. 28. The pollen diagram from Lake Halsjön I.

35 and 40 %). The values of B. nana pollen and secondary pollen grains remain rather high. The herb pollen frequency is low.

The zone is named the PINUS - EMPETRUM - BETULA NANA + secondary pollen grains Local Assemblage Zone.

- HI3 482.5 - 462.5 cm. Characterized by abundant herb pollen, with Artemisia and Gramineae pollen dominant, reaching values of more than 10 %. The frequency of shrub pollen also increases compared to zone HI2. Juniperus pollen reaches frequencies between 4 and 8 % and Salix pollen attains values between 3 and 5 %. The values of Chenopodiaceae, Dryas, Rumex, Thalictrum and Cyperaceae pollen are all higher than in zone HI2.
- This zone is named the ARTEMISIA - GRAMINEAE - JUNIPERUS - SALIX - CHENOPODIACEAE Local Assemblage Zone.

- HI4 462.5 - 432.5 cm. This zone is characterized by high values of Pinus pollen (40 %). The frequency of Artemisia is still rather high and the B. nana pollen values reach about 5 %. Compared to zone HI3 the values of herb pollen are low.
- The zone is named the PINUS - ARTEMISIA - BETULA NANA Local Assemblage Zone.

- HI5 432.5 - 422.5 cm. This rather complex zone is characterized by increasing values of Betula undiff. and dwarf-shrub pollen. Empetrum pollen reaches a frequency of about 4 %. The frequency of grass pollen is high in the lowermost part of the zone.
- This zone is named the PINUS - EMPETRUM - JUNIPERUS - BETULA undiff. Local Assemblage Zone.

- HI6 422.5 - 420 cm. This zone, the uppermost recorded from Halsjön I, is characterized by a total dominance of tree pollen, which in total reaches a value of 83 %.
- The zone is named the BETULA undiff. - PINUS Local Assemblage Zone.

No radiocarbon analyses have been carried out from Halsjön I.

5.10.4. Determination of the isolation level

The isolation pattern in Halsjön seems to be very complex. The clay of layer 1 looks like a typical Baltic Ice Lake clay. But it is obvious from Fig. 28 that rather large changes, in the microfossil content and the physical properties of layer 1, occur between samples 3 and 4. The values of Isoëtes and Sphagnum spores, Pinus pollen, secondary pollen grains and the magnetic susceptibility decrease, while the frequency of Pediastrum colonies increases. In samples 6 and 7 a return to the conditions in samples 1, 2 and 3 seems to occur. Between samples 7 and 8 the values of Isoëtes and Sphagnum spores, Pinus pollen, secondary pollen grains and the magnetic susceptibility decrease again and the frequencies of Pediastrum and Botryococcus colonies and loss on ignition increase rather rapidly. The same development occurs again between samples 16 and 17, after what seems to have been a transitory return to the conditions in samples 1, 2, 3, 6 and 7. This means that Halsjön may have been isolated three times. The first isolation occurred in zone HI2 and the second one corresponds to the lowermost part of HI3. The last isolation seems to have taken place in the upper part of zone HI4. A more detailed analysis and discussion, especially concerning the relationship of these complex sediment profiles with water level changes, will be dealt with later in Chapter 7.

5.11. Halsjön II (10b)

5.11.1. Description of the site

The same as site 10a.

5.11.2. Sediment stratigraphy

After preliminary investigations with the Russian sampler, corings with a 100 mm Livingstone piston corer were carried out in the winter of 1978. The sampling point is situated 150 m north of the coring point for Halsjön I and is situated just outside the mire (Fig. 26). The water depth is 0.1 m and the sediments between 0.1 and 3.40 metres below the water surface were not examined.

340	- 358	cm	Layer 11. Fine detritus gyttja, brown. Composition: Ld 4. Lower boundary transitional.
358	- 476	cm	Layer 10. Slightly clayey fine detritus gyttja, green-grey. Composition: Ld 3, As 1. Lower boundary sharp.
476	- 489.5	cm	Layer 9. Clayey gyttja, brownish black. Composition: Ld 2, As 2. Lower boundary sharp.
489.5	- 497.5	cm	Layer 8. Clay gyttja, greenish brown. Composition: As 3, Ld 1. Lower boundary sharp.
497.5	- 502.5	cm	Layer 7. Slightly muddy clay, green-grey. Composition: As 4, Ld 0.5. Lower boundary sharp.
502.5	- 506.5	cm	Layer 6. Muddy clay, brown. Composition: As 3, Ld 1. Lower boundary sharp.
506.5	- 508.5	cm	Layer 5. Slightly muddy clay, green-grey. Composition: As 4, Ld 0.5. Lower boundary sharp.
508.5	- 517	cm	Layer 4. Muddy clay, greyish brown. Composition: As 3, Ld 1. Lower boundary sharp.
517	- 525	cm	Layer 3. Slightly muddy clay, brown-grey. Composition: As 4, Ld 0.5. Lower boundary sharp.
525	- 526.5	cm	Layer 2. Clay with plant remains, grey. Composition: As 3, Th 1. Lower boundary sharp.
526.5	- 613	cm	Layer 1. Clay, grey. Composition: As 3, Ag 1.

No signs of lamination have been found in layer 1. Layers 10 and 11 are not included in the diagram (Fig. 29).

5.11.3. Pollen stratigraphy

The analysed profile from Halsjön II (Fig. 29) represents the sediments between 5.70 and 4.78 metres below the water surface. Within this profile 26 levels have been analysed, and the pollen diagram has been divided into nine local pollen assemblage zones (HII1-HII9).

HII1 570 - 555 cm. This is the lowest recorded zone from Halsjön II, and it is characterized by high values of

Halsjön II 30 masl

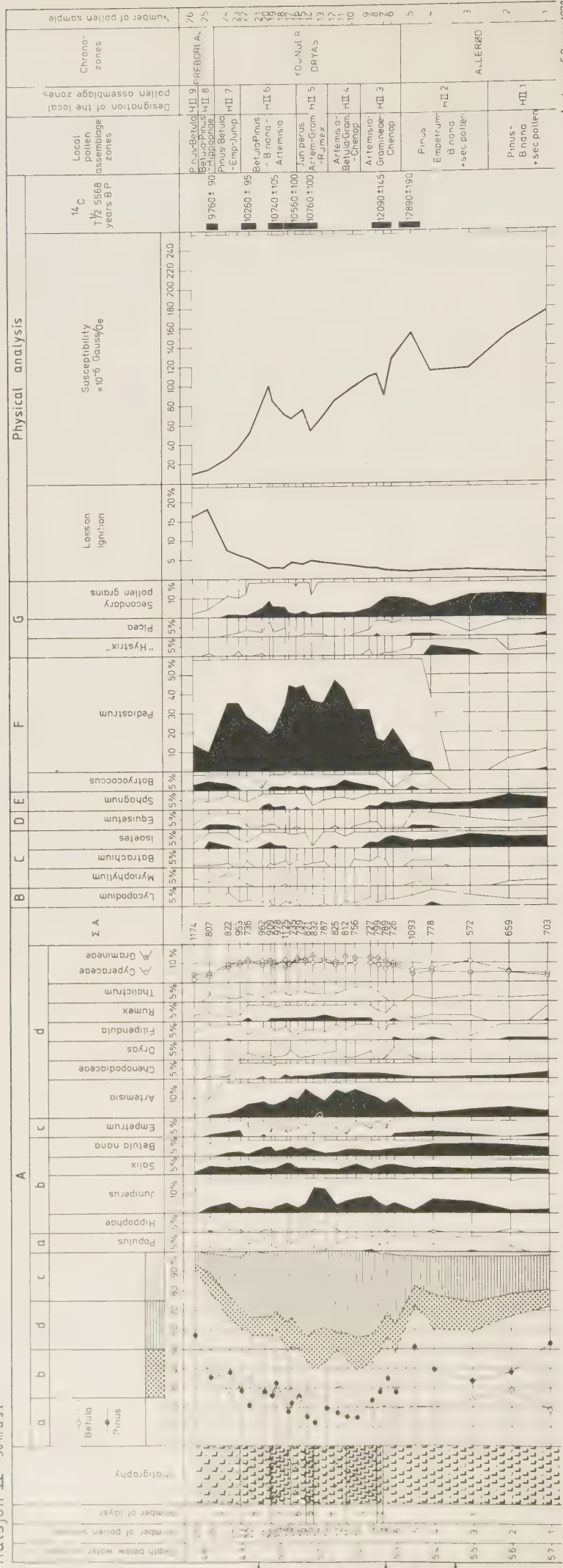


Fig. 29. The pollen diagram from Lake Halsjön II.

Analysis S Björck 1978

tree pollen, with Pinus pollen dominant, reaching frequencies between 38 and 53 %. B. nana pollen reaches a frequency of about 5 %. The herb pollen values are low and the values of secondary pollen grains reach more than 10 %.

This zone is named the PINUS - BETULA NANA + secondary pollen grains Local Assemblage Zone.

HII2 555 - 532.5 cm. Compared to zone HII1 the most marked change are the increasing values of Empetrum pollen (between 1 and 3 %). The frequencies of Juniperus pollen are also relatively high, but reach even higher values further up in the stratigraphy.

The zone is named the PINUS - EMPETRUM - BETULA NANA + secondary pollen grains Local Assemblage Zone.

HII3 532.5 - 522 cm. Characterized by high values of herb pollen. Artemisia and Gramineae pollen reach values of more than 10 %, and Chenopodiaceae pollen attains frequencies of almost 3 %. Compared to zone HII2 the frequencies of Pinus, Empetrum and B. nana pollen decrease very markedly. The values of Juniperus and Cyperaceae pollen are relatively high.

This zone is named the ARTEMISIA - GRAMINEAE - CHENOPODIACEAE Local Assemblage Zone.

HII4 522 - 513.5 cm. Compared to zone HII3, the only significant change are the increasing values of Betula undiff. pollen, reaching frequencies between 23 and 31 %. The zone is named the ARTEMISIA - BETULA undiff. - GRAMINEAE - CHENOPODIACEAE Local Assemblage Zone.

HII5 513.5 - 507 cm. Except for the high values of herb pollen, this zone is characterized by high values of Juniperus pollen, reaching a frequency of more than 13 %. Compared to zone HII4 the values of Betula undiff. and Chenopodiaceae pollen decrease, while the values of Rumex pollen increase (between 2 and 3 %). This zone is named the JUNIPERUS - ARTEMISIA - GRAMINEAE - RUMEX Local Assemblage Zone.

- HII6 507 - 492 cm. Characterized by increasing values of tree pollen. Pinus pollen reaches frequencies between 18 and 33 % and Betula undiff. pollen reaches values between 24 and 35 %. B. nana pollen attains values up to 5 %. The herb pollen frequencies are not as high as in previous zones.
This zone is named the BETULA undiff. - PINUS - BETULA NANA - ARTEMISIA Local Assemblage Zone.
- HII7 492 - 484.5 cm. Compared to zone HII6, this zone is characterized by increasing frequencies of Juniperus and Empetrum pollen. The herb pollen frequency still decreases and the tree pollen value increases slowly.
The zone is named the PINUS - BETULA undiff. - ENPETRUM - JUNIPERUS Local Assemblage Zone.
- HII8 484.5 - 480 cm. This zone is characterized by high values of Pinus (36 %) and Betula undiff. pollen (43 %). Hippophaë pollen attains a frequency of more than 1 %. The values of herb and shrub pollen are low.
This zone is named the BETULA undiff. - PINUS - HIPPOPHAË Local Assemblage Zone.
- HII9 480-478 cm. This zone, the uppermost recorded from Halsjön II, is characterized by abundant tree pollen, with Pinus pollen dominant, reaching a value of almost 60 %. All other pollen types decrease, compared to zone HII8.
The zone is named the PINUS - BETULA undiff. Local Assemblage Zone.

5.11.4. Radiocarbon analyses

Altogether seven samples have been radiocarbon dated from Halsjön II (Fig. 29). The lowest dated level is between 5.38 and 5.32 metres below the water surface, and the radiocarbon age of this level, corresponding to the boundary between zones HII2 and HII3, is $12,890 \pm 190$ B.P. (Lu-1599). The sediments between 5.30 and 5.25 m, corresponding to zone HII3, was radiocarbon dated to $12,090 \pm 145$ B.P. (Lu-1600). A radiocarbon age of $10,760 \pm 100$ B.P.

(Lu-1601) was obtained for the middle part of zone HII5 (5.11 to 5.07 m). The boundary between zones HII5 and HII6 has a radiocarbon age of $10,560 \pm 100$ B.P. (Lu-1602), corresponding to the level 5.07 to 5.02 m. The middle part of zone HII6 (5.02 to 4.98 m) was radiocarbon dated to $10,470 \pm 105$ B.P. (Lu-1603), while the uppermost part of this zone (4.95 to 4.91 m) has a radiocarbon age of $10,260 \pm 95$ B.P. (Lu-1604). The uppermost dated level from Halsjön II corresponds to the sediments between 4.85 and 4.82 metres below the water surface. This level, which is approximately the same as zone HII8, has a radiocarbon age of $9,760 \pm 90$ B.P. (Lu-1605).

5.11.5. Diatom stratigraphy

In this lake many attempts have been made to investigate the diatom composition of different stratigraphic levels. However, above sample level 3 it is almost impossible to find any whole valve at all. In sample 1 197 diatoms have been counted and grouped according to Kolbe's (1927) halobian system redefined by Hustedt (1957). With the exception of two polyhalobous and two mesohalobous forms they are all oligohalobous. The composition seems to be the same in samples 2 and 3, which indicates a fresh water environment, at least up to sample 3.

5.11.6. Determination of the isolation level

As already was pointed out in connection with site 10a, the isolation pattern in this lake is very complex. In Halsjön II the first isolation seems to take place between samples 3 and 4. The values of Pediastrum and Botryococcus colonies increase, while the frequency of secondary pollen grains and Isoëtes spores decrease. The susceptibility value is low in sample 4. However, the value of "Hystrix" and Pinus pollen increase and the loss on ignition value decreases slightly and although there seems to be no change of the sediment between samples 3 and 4, a transitory isolation seems to have taken place between these two samples. Samples 5 to 7 are characterized by the same properties as samples 1 to 3 and are interpreted as being deposited during a transgression. This transgression is followed by another isolation between samples 7 and 8. Between these samples the values of Pinus pollen, Isoëtes and Sphagnum spores and "Hystrix" decrease very markedly, while

the frequencies of Botryococcus and loss on ignition increase rapidly. The only isolation indicator that diverges is the slightly increasing value of the susceptibility. According to the radiocarbon date the age of this isolation is about 12,100 years B.P., but this date will be discussed in Chapter 6. Samples 18 to 21 are characterized by relatively high values of susceptibility, secondary pollen grains, Pinus pollen, Sphagnum and Isoëtes spores and low values of loss on ignition, Pediastrum and Botryococcus colonies. The beginning of this phase is radiocarbon dated to about 10,500 years B.P., while the middle part of it has a radiocarbon age of about 10,700 years B.P., which one should pay special attention to. The whole phase is interpreted as a transgression of the Baltic Ice Lake into the basin, followed by an isolation between samples 21 and 22. This isolation is radiocarbon dated to about 10,300 years B.P. The isolation is shown by very marked reductions of the values of Pinus pollen, secondary pollen grains, Isoetes and Sphagnum spores, "Hystrix" and the susceptibility. This is supported by increasing values of Botryococcus and Pediastrum colonies and loss on ignition. Compared to Halsjön I, the development in Halsjön II seems to have been the same, which is a further support of the existence of three isolations and two transgressions at the altitude of 30 m a.s.l. in Blekinge.

5.12. F.d. Paddegölen (11)

5.12.1. Description of the site

This site is located in the southern part of the bed-rock plateau, mentioned in connection with site 9. It is situated 1 km NNW of Saxemara and about 1 km from the coast (Figs. 9 and 30). As the Swedish name reveals (f.d. = former, göl = pool), there has previously been open water in the basin. The old economic map shows that it was still a pool during the early 1920's. Nowadays it can be characterized as a bog with a schwing moore in the middle of the basin. The threshold of the basin is situated 500 m NE of the site (Fig. 30) and consists of bed-rock. It is quite obvious that the outflow channel existing today must have been blasted. This lowered the water level of the former pool by about 2.5 metres, according to field investigations. The upper surface of the threshold is, according to the new economic map, situated between

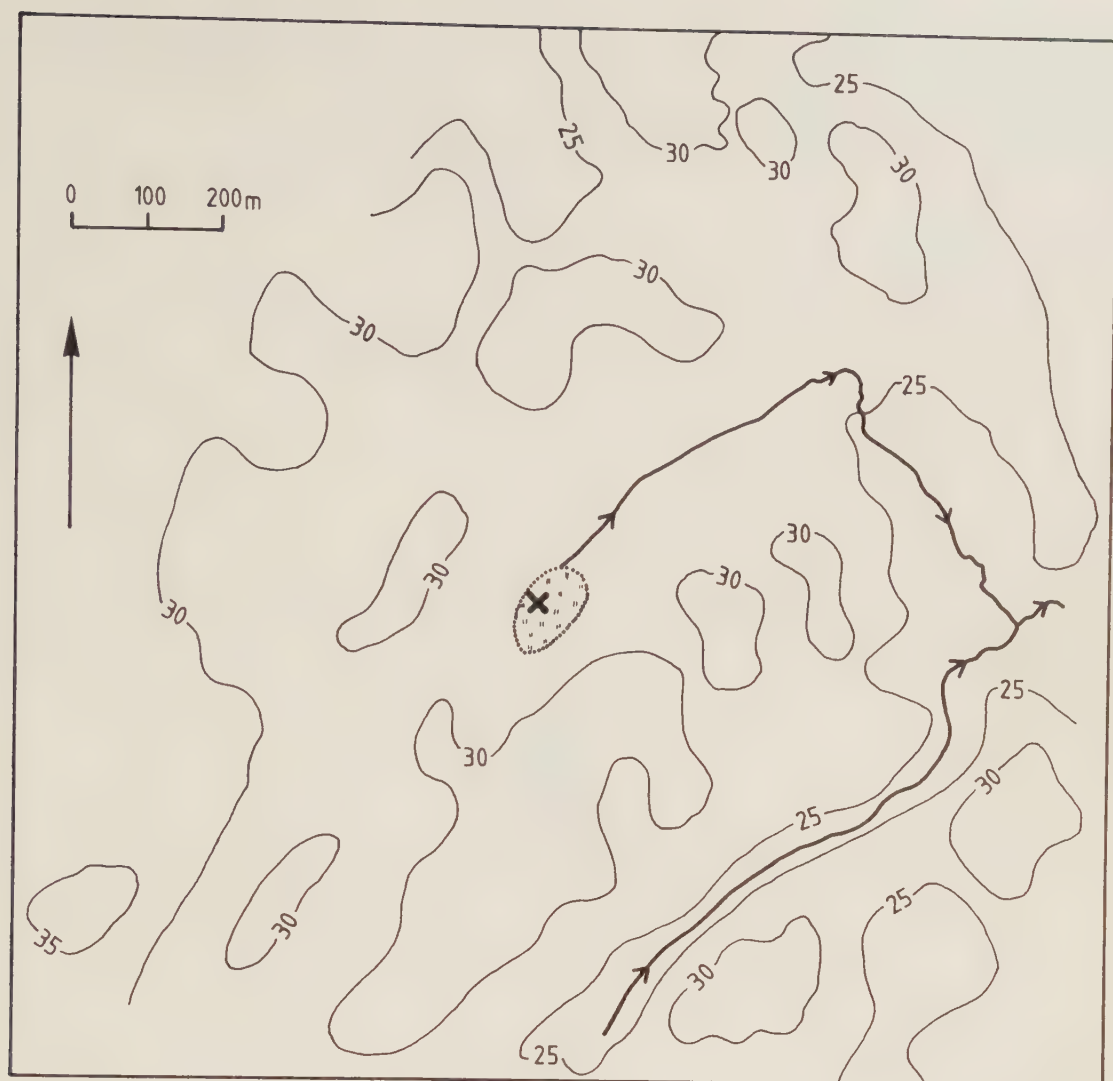


Fig. 30. The local topographic position of the previous Lake Paddegölen. The cross marks the coring point.

27 and 28 m a.s.l. The original altitude of the threshold is thus estimated at 27.5 m a.s.l.

F.d. Paddegölen is surrounded by bed-rock, sometimes covered by till. The hollows in the bed-rock are usually filled with organic deposits.

5.12.2. Sediment stratigraphy

The basin was carefully investigated with a Russian sampler before the final sampling point was selected. It is situated in the middle western part of f.d. Paddegölen. The depth figure given in the text below and in the diagram (Fig. 31) corresponds to the depth below the bog surface. The sediments down to 5.2 m were not examined.

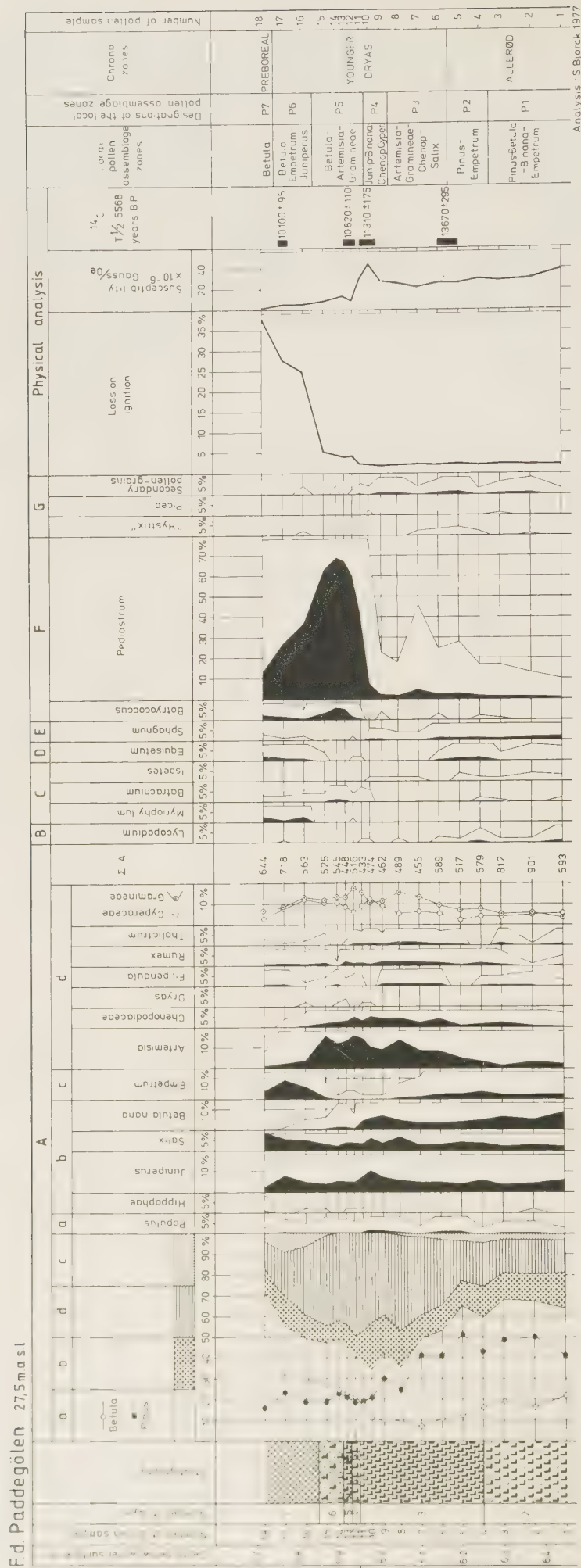


Fig. 31. The pollen diagram from the previous Lake Paddegölen.

520 - 585 cm	Layer 7. Fine detritus gyttja, brownish black. Composition: Ld 4. Lower boundary diffuse.
585 - 591 cm	Layer 6. Clayey fine detritus gyttja, dark-brown. Composition: Ld 3, As 1. Lower boundary sharp.
591 - 593 cm	Layer 5. Muddy clay, very light-brown. Composition: As 4, Ld 0.5. Lower boundary sharp.
593 - 595 cm	Layer 4. Clay gyttja, green-brown. Composition: As 3, Ld 1. Lower boundary sharp.
595 - 625 cm	Layer 3. Clay, blue-grey. Composition: As 4. Lower boundary transitional.
625 - 695 cm	Layer 2. Slightly silty clay, bluish brown-grey. Composition: As 3, Ag 1. Lower boundary diffuse.
695 - 718 cm	Layer 1. Clay, brown. Composition: As 4, Th+. Plant remains at 7.00 m.

No lamination was found in the clay. Layer 1 is not included in the diagram.

5.12.3. Pollen stratigraphy

The pollen diagram shown in Fig. 31 represents the sediments between 6.45 and 5.72 metres below the bog surface. Within these 73 centimetres 18 levels have been analysed and the diagram has been divided into seven local pollen assemblage zones (P1-P7).

P1 645 - 627.5 cm. This is the lowest recorded zone in f.d. Paddegölen. It is characterized by abundant tree pollen, with Pinus pollen dominant, reaching values between 41 and 48 %. The frequency of Betula undiff. pollen varies between 16 and 22 %. B. nana pollen has frequencies of 5 %, or more. Dwarf-shrub pollen reaches comparatively high values. The total herb pollen values do not reach higher frequencies than 16 %.

This zone is named the PINUS - BETULA undiff. - BETULA NANA - EMPETRUM Local Assemblage Zone.

P2 627.5 - 617.5 cm. The only significant change compared to zone P1 is the decreasing values of Betula undiff. and

B. nana pollen and a tendency towards slowly increasing values of herb pollen.

The zone is named the PINUS - EMPETRUM Local Assemblage Zone.

- P3 617.5 - 603 cm. Characterized by high values of herb pollen and rapidly decreasing values of Pinus pollen. Artemisia pollen values are between 8 and 14 %. Gramineae pollen reaches a frequency of 10 % or more. The values of Chenopodiaceae pollen are comparatively high throughout the zone. At the end of the zone, Salix pollen reaches a value of 12 %. The values of Betula undiff. pollen reaches a maximum of 11 %.
- This zone is named the ARTEMISIA - GRAMINEAE - CHENOPODIACEAE - SALIX Local Assemblage Zone.
- P4 603 - 597 cm. Characterized by high values of Juniperus (between 8 and 10 %) and B. nana pollen (more than 5 %). High frequencies of herb pollen. Chenopodiaceae pollen reaches values of 4 %, or more. Cyperaceae pollen attains values of about 10 %.
- The zone is named the JUNIPERUS - BETULA NANA - CHENOPODIACEAE - CYPERACEAE Local Assemblage Zone.
- P5 597 - 584 .5 cm. Characterized by increasing values of Betula undiff. pollen (from 17 to 27 %). Still rather high frequencies of herb pollen with Artemisia and Gramineae pollen dominant, reaching values of 10 % or more. The values of shrub pollen decrease.
- This zone is named the BETULA undiff. - ARTEMISIA - GRAMINEAE Local Assemblage Zone.
- P6 584.5 - 575 cm. This zone is characterized by high values of Empetrum pollen reaching frequencies between 6 and 9 %. The values of Betula undiff. pollen are still high and Juniperus pollen reaches values of 5 % or more. The frequency of herb pollen decreases.
- The zone is named the BETULA undiff. - EMPETRUM - JUNIPERUS Local Assemblage Zone.

P7 575 - 572 cm. Characterized by abundant Betula undiff. pollen, reaching a value of 55 %. With the exception of Hippophaë, Salix and Betula undiff. pollen, the values of all pollen types decrease.

The zone is named the BETULA undiff. Local Assemblage Zone.

5.12.4. Radiocarbon analyses

Four levels from the analysed profile have been radiocarbon dated. The lowest dated sample is situated between 6.20 and 6.15 metres below the bog surface. This level corresponds to the boundary between zones P2 and P3. The ^{14}C -age was $13,670 \pm 295$ B.P. (Lu-1471). The boundary between zones P4 and P5 has also been radiocarbon dated and the sediment from 6.00 to 5.96 m had a ^{14}C -age of $11,310 \pm 175$ B.P. (Lu-1472). The third ^{14}C -dated level is situated between 5.95 and 5.92 m and corresponds to the lower part of zone P5. The radiocarbon age obtained was $10,820 \pm 110$ B.P. (Lu-1473). The uppermost dated level is situated between 5.785 and 5.760 m and corresponds to the upper part of zone P6. The ^{14}C -age of this sample was $10,000 \pm 95$ B.P. (Lu-1474). These partly very high ages will be discussed in Chapter 6.

5.12.5. Diatom stratigraphy

In f.d. Paddegölen samples 9 to 14 have been analysed in respect of the composition of the diatom flora. Samples 9 and 10 are relatively rich in diatoms (544 and 295 respectively), while only 20 diatoms were counted in sample 11. In samples 12 to 14 only one (1) diatom has been counted altogether, and these samples are characterized by yellow-brown accumulations. According to Kolbe's (1927) halobian grouping redefined by Hustedt (1957), the oligohalobous forms dominate completely. Only one mesohalobous and one polyhalobous form has been found. This indicates a fresh water environment in at least sample levels 9 and 10 and probably also in sample level 11.

5.12.6. Determination of the isolation level

The clayey sediments of layers 1, 2 and 3 are homogenous. They can be related to the Baltic Ice Lake with certainty. It is quite

obvious from the diagram (Fig. 31) that an important change in sedimentation occurs between layers 3 and 4 and between samples 11 and 12. The most significant changes are the increasing values of Pediastrum colonies and the decreasing values of the magnetic susceptibility. These changes are also supported by changing values of Sphagnum spores, Botryococcus colonies, secondary pollen grains and loss on ignition.

Sample 12 is most likely the first isolated sample in f.d. Paddegölen. The isolation from the Baltic Ice Lake is thus dated to the lower part of zone P5, which has been radiocarbon dated to 10,820 B.P. (Fig. 31). This date will be discussed in Chapters 6 and 7.

5.13. Norrsjön (12)

5.13.1. Description of the site

This comparatively small lake is located 3 km west of Bräkne-Hoby and 7 km from the coast (Fig. 9). It is now situated at 24 m a.s.l. but old documents and the old economic map shows that the outflow of the basin has been moved from the northeastern part of the lake to the western part in order to obtain pastures. The present threshold, located 200 m west of the lake, consists of bed-rock which has been blasted. According to the old documents and field studies the lake was lowered about 1 m. This means that the original level of the lake was about 25 m a.s.l.

The lake is situated in a narrow basin surrounded by bed-rock ridges both northwards and southwards. These ridges reach altitudes of more than 50 m a.s.l. and are sometimes covered by till. The outflow passes through very narrow bed-rock dependent passages. Just east of the lake, organic silt and sand dominate. Between this area and the valley of Bräkneån the ground is uneven and dominated by till. Clay is rather common in the lowest parts of the area, south and west of the lake.

5.13.2. Sediment stratigraphy

In the winter of 1976 corings were carried out with a Russian sampler. The water depth at the main sampling point, situated in

the middle of the lake, is 2.5 m. The sediments between 2.5 and 6.5 metres below the water surface were not examined.

650 - 735 cm	Layer 5. Fine detritus gyttja, brown. Composition: Ld 4. Lower boundary diffuse.
735 - 747 cm	Layer 4. Clayey fine detritus gyttja, grey-brown. Composition: Ld 3, As 1. Lower boundary diffuse.
747 - 755 cm	Layer 3. Clay gyttja, light green-brown. Composition: As 3, Ld 1. Lower boundary diffuse.
755 - 775 cm	Layer 2. Muddy clay, greenish grey. Composition: As 4, Ld 0.5. Lower boundary diffuse.
775 - 1035 cm	Layer 1. Clay, grey. Composition: As 4.

The clay of layer 1 is very indistinctly laminated, but the lamination does not seem to consist of varves but rather of chemically produced layers.

5.13.3. Pollen stratigraphy

The profile analysed (Fig. 32) comprises the sediments between 8.20 and 7.32 metres below the water surface and within these 98 cm, 15 levels have been analysed. The pollen diagram has been divided into six local pollen assemblage zones (N1-N6).

- N1 820 - 805 cm. This is the lowest recorded zone from Norrsjön. It is characterized by a rather high frequency of herb pollen. Artemisia pollen reaches values between 9 and 15 % and Chenopodiaceae pollen attains a value of more than 5 %. Among shrub pollen Salix pollen is dominant, reaching frequencies between 3 and 7 %. Hippophaë pollen attains a maximum value of more than 2 %. The frequency of tree pollen in this zone is the lowest within the whole profile. Secondary pollen grains reach values between 12 and 16 %.
- The zone is named the ARTEMISIA - SALIX - CHENOPODIACEAE - HIPPOPHAË + secondary pollen grains Local Assemblage Zone.

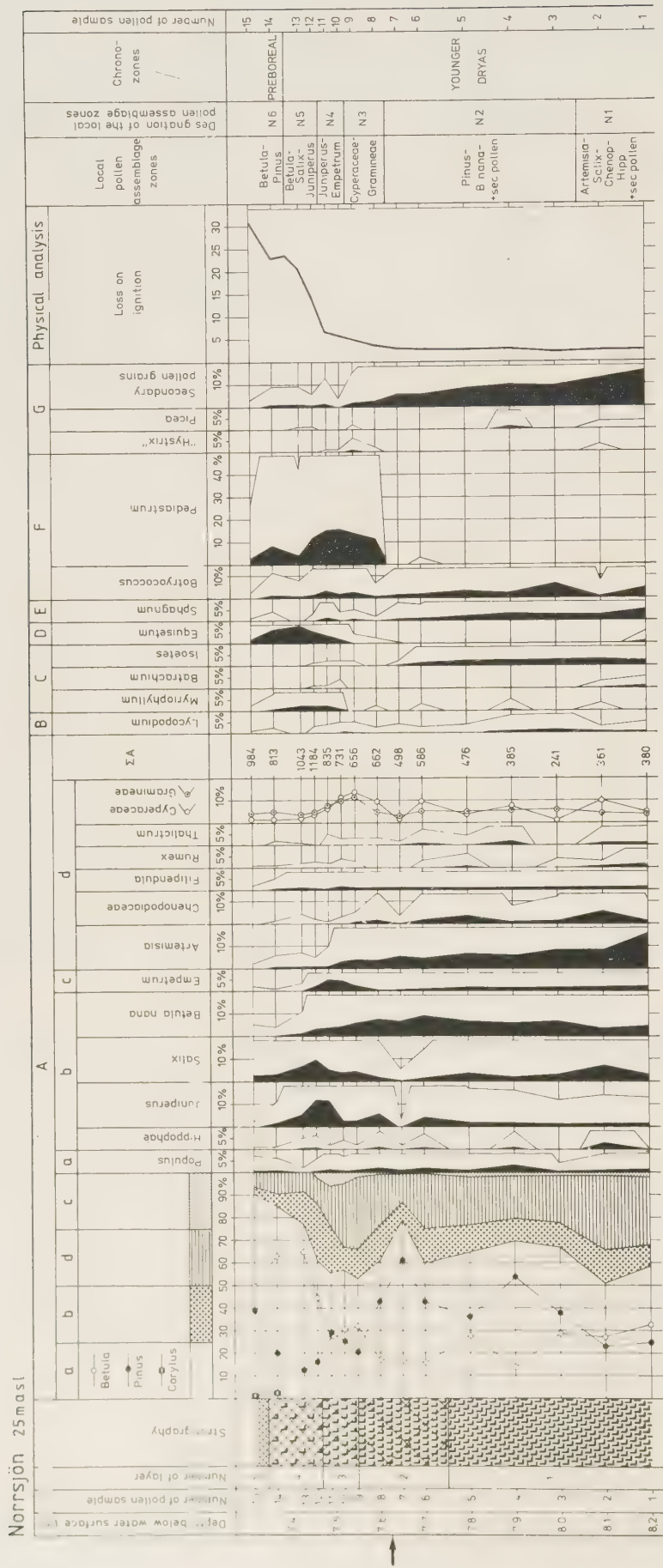


Fig. 32. The pollen diagram from Lake Norrsjön.

- N2 805 - 762.5 cm. Characterized by rapidly increasing values of Pinus pollen compared with zone N1, reaching frequencies between 36 and 61 %. The values of B. nana pollen are relatively high throughout the zone, with a frequency of 5 % or more. The values of herb and Betula undiff. pollen are low. The frequency of secondary pollen grains decreases, but the values are never lower than 5 %.
- This zone is named the PINUS - BETULA NANA + secondary pollen grains Local Assemblage Zone.
- N3 762.5 - 754 cm. This zone is characterized by abundant herb pollen, with grass pollen dominant, reaching values between 14 and 25 % in total. The values of Pinus pollen decrease suddenly, compared to zone N2, as do those of secondary pollen grains.
- The zone is named the CYPERACEAE - GRAMINEAE Local Assemblage Zone.
- N4 754 - 747.5 cm. Characterized by increasing values of shrub and dwarf-shrub pollen compared with zone N3. Empetrum pollen attains a frequency of 5 % or more. Juniperus pollen reaches a value of more than 11 %. Grass and Artemisia pollen values decrease rapidly compared to zone N3.
- This zone is named the JUNIPERUS - EMPETRUM Local Assemblage Zone.
- N5 747.5 - 740 cm. Characterized by abundant Betula undiff. pollen, reaching values between 45 and 65 %. The values of herb pollen are very low, while the frequency of shrub pollen is high. Juniperus pollen reaches a value of almost 12 % and Salix pollen has a maximum value of about 10 % in the lowermost part of the zone. The frequency of Empetrum pollen is negligible.
- The zone is named the BETULA undiff. - SALIX - JUNIPERUS Local Assemblage Zone.
- N6 740 - 732 cm. This zone, the uppermost recorded, is totally dominated by tree pollen, reaching a value of

almost 90 %. The frequency of shrub pollen decreases very rapidly.

This zone is named the BETULA undiff. - PINUS Local Assemblage Zone.

No radiocarbon analyses have been carried out from Norrsjön.

5.13.4. Determination of the isolation level

The clay of layer 1 is a typical nonvarved Baltic Ice Lake clay and the boundary between layers 1 and 2 is very diffuse. As stated earlier, an isolation contact is sometimes difficult to determine visually. This is also the case in Norrsjön. However, within layer 2, between samples 7 and 8, a major change occurs in the microfossil content (Fig. 32). Between these two samples the amount of Pediastrum colonies increases very markedly, and the decreasing values of Pinus pollen, Isoëtes and Sphagnum spores and secondary pollen grains are also prominent. The interpretation of sample 8 being the first isolated sample in the profile from Norrsjön is also supported by the increasing value of loss on ignition. The relative age of the suggested isolation of Norrsjön corresponds to the boundary between zones N2 and N3.

5.14. F.d. Togölen (13)

5.14.1. Description of the site

This basin is located 2.5 km SSW of Ronneby and 3 km from the coast (Fig. 9). The basin today is occupied by a bog with the bog surface situated between 15 and 20 m a.s.l. It is obvious as much from the name of the site as from the appearance of the threshold that the basin has been drained. The threshold, situated in the western part of the bog, consists of bed-rock and has without doubt been blasted. This lowered the threshold by about 3 m. According to the new maps of the area, the bog reaches up to the 20 m contour line at some places. The bed-rock surface at the threshold is also situated at the 20 m contour line. These facts have been used to estimate the original level of the former pool to about 20 m a.s.l.

The nearest surroundings of f.d. Togölen consist of bed-rock and till. Just west of the basin lies a beautiful fissure valley. The valley is dominated by clayey and silty deposits.

5.14.2. Sediment stratigraphy

Coring in f.d. Togölen was carried out in the winter of 1977 with a Russian sampler. The final sampling point is situated in the middle of the eastern part of the bog. The sediments between 0.0 and 4.8 metres below the bog surface were not classified.

450 - 510 cm	Layer 4. Fine detritus gyttja, brown. Composition: Ld 4. Lower boundary sharp.
510 - 514 cm	Layer 3. Clay gyttja, brown-grey. Composition: As 3, Ld 1. Lower boundary gradual.
514 - 528 cm	Layer 2. Muddy clay, grey. Composition: As 3.5, Ld 0.5. Lower boundary diffuse.
528 - 735 cm	Layer 1. Slightly muddy clay, grey. Composition: As 4, Ld+.

No lamination was found in layer 1, which seems to be a very homogenous sediment.

5.14.3. Pollen stratigraphy

The pollen analysed profile (Fig. 33) contains 24 analysed levels between 6.30 and 5.03 metres below the bog surface. The pollen diagram has been divided into eight local pollen assemblage zones (T1-T8).

- T1 630 - 617.5 cm. This zone, the lowest recorded from f.d. Togölen, is characterized by abundant tree pollen, with Pinus pollen dominant, reaching values of 40 % or more. Artemisia pollen attains frequencies between 5 and 9 % and the Chenopodiaceae pollen values are higher than 5 %. B. nana pollen attains values of about 5 % and the Gramineae and Cyperaceae pollen values do not exceed 15 % in total.
- The zone is named the PINUS - ARTEMISIA - CHENOPODIACEAE -

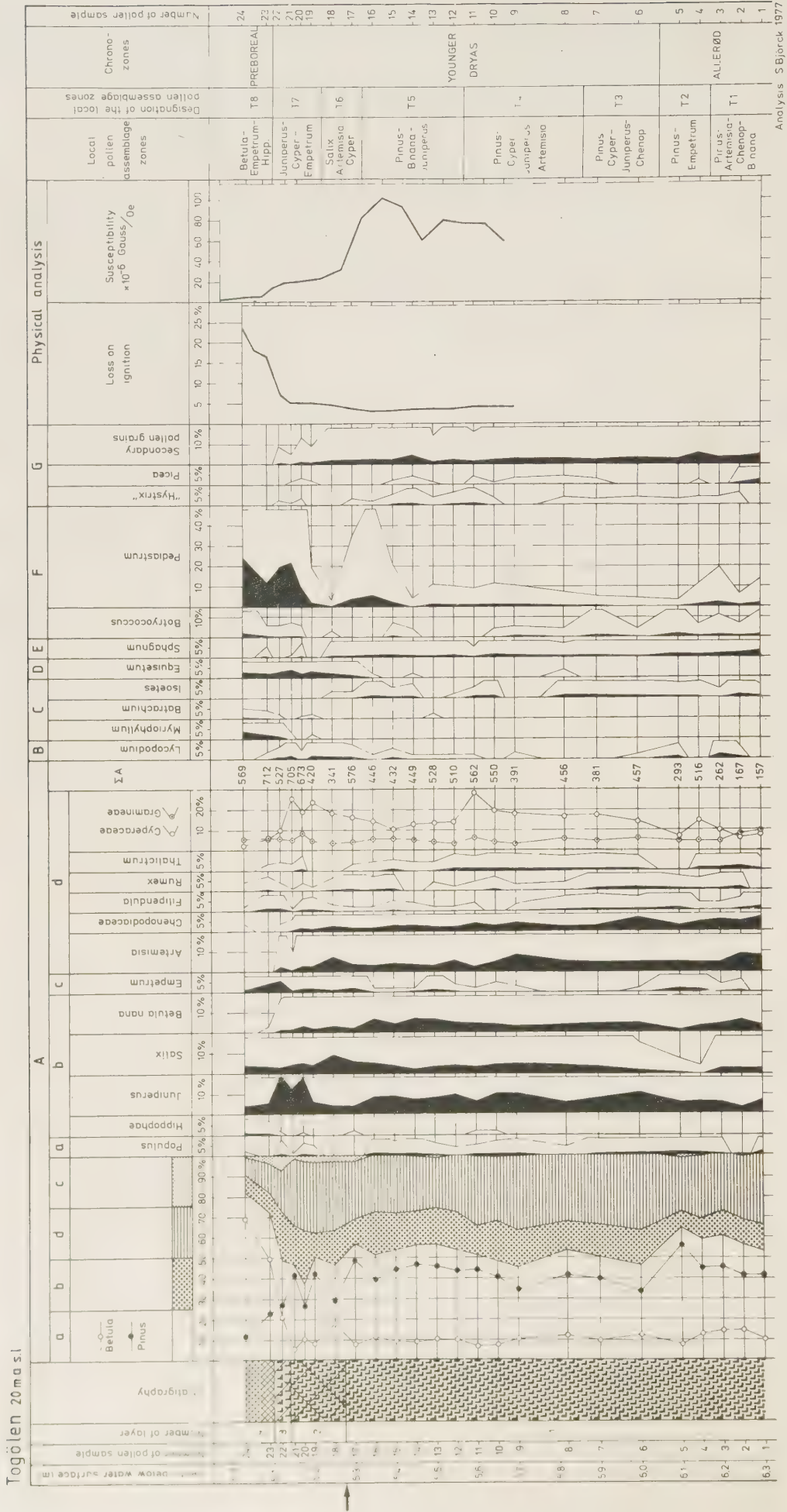


Fig. 33. The pollen diagram from the previous Lake Togölen.

BETULA NANA Local Assemblage Zone.

- T2 617.5 - 605 cm. Characterized by a Pinus pollen value of more than 55 % and increasing values of Empetrum compared with zone T1. The values of all other pollen types are comparatively low.
This zone is named the PINUS - EMPETRUM Local Assemblage Zone.
- T3 605 - 586 cm. This zone is characterized by increasing values of herb and shrub pollen and decreasing, but still rather high, values of Pinus pollen compared with zone T2. Cyperaceae pollen attains values between 15 and 20 % and Chenopodiaceae pollen reaches frequencies between 3 and 7 %. The values of Juniperus pollen reach 8 % or more. The frequency of Betula undiff. pollen is very stable (about 10 %).
The zone is named the PINUS - CYPERACEAE - JUNIPERUS - CHENOPODIACEAE Local Assemblage Zone.
- T4 586 - 557.5 cm. The only significant change within this zone compared with zone T3 is the decreasing values of Chenopodiaceae pollen and the increasing frequencies of Artemisia pollen.
This zone is named the PINUS - CYPERACEAE - JUNIPERUS - ARTEMISIA Local Assemblage Zone.
- T5 557.5 - 532.5 cm. Characterized by increasing values of Pinus pollen (more than 40 %) compared with zone T4. The frequencies of Artemisia and Cyperaceae pollen decrease, while the B. nana pollen values increase.
The zone is named the PINUS - BETULA NANA - JUNIPERUS Local Assemblage Zone.
- T6 532.5 - 522.5 cm. Characterized by comparatively high values of Salix (5 to 10 %), Artemisia (4 to 8 %) and Cyperaceae pollen (more than 15 %), while the frequencies of Pinus, Juniperus and B. nana pollen decrease markedly compared with zone T5. The values of Empetrum pollen

increase slowly.

This zone is named the SALIX - ARTEMISIA - CYPERACEAE Local Assemblage Zone.

- T7 522.5 - 510.5 cm. This zone is characterized by abundant shrub pollen, with Juniperus pollen dominant, reaching values of almost 20 %. Among the herb pollen Cyperaceae pollen dominates completely, attaining frequencies between 20 and 25 %. Empetrum pollen attains its highest value (6 %) of the whole profile.
- The zone is named the JUNIPERUS - CYPERACEAE - EMPETRUM Local Assemblage Zone.
- T8 510.5 - 503 cm. This zone, the uppermost recorded from f.d. Togölen, is dominated by high values of tree pollen (more than 70 %). For the first time Betula undiff. pollen reaches values higher than 18 %, and at the top of this zone attains a value of about 70 %. The Pinus pollen values decrease very markedly compared with zone T7. The values of Empetrum pollen are still comparatively high. The frequencies of Hippophaë pollen reach 1 % almost and Filipendula pollen values attain comparatively high frequencies.
- This zone is named the BETULA undiff. - EMPETRUM - HIPPOPHAË Local Assemblage Zone.

No radiocarbon analyses have been carried out from f.d. Togölen.

5.14.4. Determination of the isolation level

Although layer 1 contains some organic matter, it is presumed to have been deposited in the Baltic Ice Lake. The reasons for this are the visual similarities to a Baltic Ice Lake clay, the low values of Pediastrum colonies and loss on ignition and the high values of the magnetic susceptibility. The frequency of secondary pollen grains is more or less constant throughout layer 1 but decreases in layer 2. Between samples 17 and 18 other changes also occur. Except for the decreasing values of the magnetic susceptibility and the increasing frequencies of loss on ignition, Sphagnum and Isoëtes spores almost disappear and the Pinus pollen curve decreases rapidly. Although the values of Pediastrum colonies

decrease rather than increase between samples 17 and 18, they are high in samples 20 and 21. With the exception of the values of Pediastrum colonies, sample 18 looks like being the first isolated sample within the profile from f.d. Togölen. If this interpretation is correct, the basin was isolated from the Baltic Ice Lake in the middle of zone T6.

5.15. Getsjön (14)

5.15.1. Description of the site

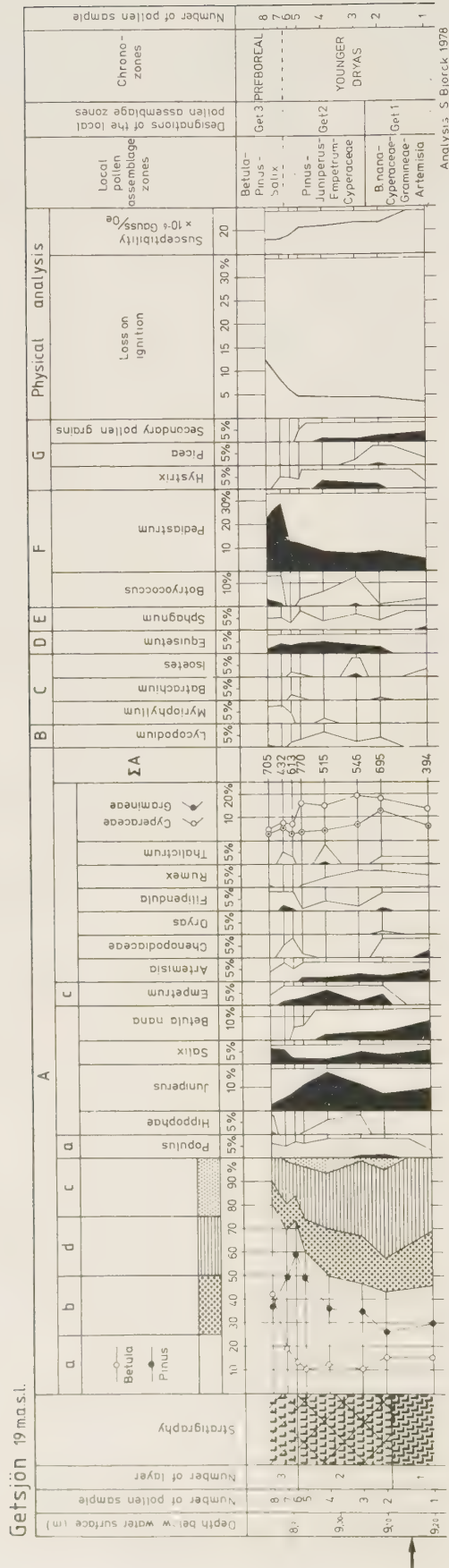
This basin is located 6 km WSW of Ronneby and 3 km from the coast (Fig. 9). The lake today is situated 17 m a.s.l. Evidence of a lowering of the threshold has not been found, either in old documents or from the old economic map. Without doubt, however, the the threshold, situated in the northwestern part of the basin and consisting of bed-rock and till, has been deepened by man. The rather deep channel existing as an outflow today is estimated to be about 2 m lower than the original threshold. This means that the original level of the lake was situated about 19 m a.s.l.

The area in the vicinity of the lake is characterized by till and bed-rock. North of the lake the bed-rock reaches altitudes of more than 50 m a.s.l. The area is very rich in fissure valleys of which the Vierydså valley, west of Getsjön, is the most prominent one. In these fissure valleys clayey and silty deposits are very common. Getsjön is situated on the bed-rock plateau mentioned in connection with site 9.

5.15.2. Sediment stratigraphy

In the winter of 1978 coring was carried out with a Russian sampler. The sampling point is situated 75 m from the northern shore and the water depth is 5.40 m. The sediments between 5.40 and 8.50 metres below the water surface have not been examined.

850 - 881 cm	Layer 4. Slightly clayey fine detritus gyttja, brown.
	Composition: Ld 4, As+. Lower boundary diffuse.



- 891 - 911 cm Layer 2. Muddy clay, light-brown.
Composition: As 4, Ld 0.5. Lower boundary diffuse.
- 911 - 1050 cm Layer 1. Slightly muddy clay, brown-grey.
Composition: As 4, Ld+.

No lamination has been found in layer 1. Layer 4 is not included in the pollen diagram.

5.15.3. Pollen stratigraphy

The pollen diagram (Fig. 34) represents the sediments between 9.20 and 8.86 metres below the water surface. Within these 34 cm, 8 levels have been analysed and the profile analysed has been divided into three local pollen assemblage zones (Get1-Get3).

- Get1 920 - 907.5 cm. This zone is characterized by abundant herb pollen, with grass pollen dominant, reaching values between 20 and 30 %. Artemisia pollen attains frequencies between 2.5 and 5 %. Among shrub pollen, Juniperus and B. nana pollen are dominant. B. nana pollen reaches a maximum value of 8 %, but Juniperus pollen attains higher values in zone Get2.
The zone is named the BETULA NANA - CYPERACEAE - GRAMINEAE - ARTEMISIA Local Assemblage Zone.
- Get2 907.5 - 890 cm. Characterized by increasing values of Pinus (35 to 60 %), Juniperus (between 8 and 16 %) and Empetrum pollen (between 2 and 6 %) compared with zone Get1. The frequencies of Cyperaceae pollen remain high, while the values of Artemisia and Gramineae pollen decrease.
This zone is named the PINUS - JUNIPERUS - EMPETRUM - CYPERACEAE Local Assemblage Zone.
- Get3 890 - 886 cm. This zone, the uppermost recorded from Getsjön, is characterized by high values of tree pollen, reaching frequencies between 70 and 80 %. As well as Pinus and Betula undiff. pollen, this zone is also characterized by rather high values of Salix pollen

(more than 6 %).

The zone is named the BETULA undiff. - PINUS - SALIX
Local Assemblage Zone.

The sediments from Getsjön have not been radiocarbon dated.

5.15.4. Determination of the isolation level

The clay of layer 1 is regarded as being a sediment deposited in the Baltic Ice Lake. This is supported by the microfossil content and the physical properties of layer 1. The values of Pediastrum colonies and loss on ignition are comparatively low, while the values of Pinus pollen, Sphagnum spores, secondary pollen grains and magnetic susceptibility decrease between samples 1 and 2. Relatively large changes also occur between samples 6 and 7, but these changes are interpreted as being a consequence of a climatic amelioration. The boundary between layers 1 and 2 is thus regarded as the most plausible level for the isolation contact. This means that Getsjön became isolated from the Baltic Ice Lake in the uppermost part of zone Get1.

5.16. Harstorpssjön (15)

5.16.1. Description of the site

This rather large lake is located 1 km southwest of Ronneby and 4 km from the coast (Fig. 9). It is situated 17.7 m a.s.l. According to old documents the level of the lake has been regulated during at least the last 50 years. The threshold, situated in the very southern part of the basin, is made up by sand and gravel. The outflow consists of a dyke, about 1 m deep, which has been at least partially dug by man. As the original threshold of the lake seems to have been situated about 1 m above present water level, the original level of the lake is estimated at 18.5 m a.s.l.

Harstorpssjön is situated in a fissure valley, which reaches the coast 3 km further south. The surroundings of the lake are characterized by a rather uneven topography consisting of bed-rock and till. The highest level reaches up to about 50 m a.s.l. North of the lake, in a rather narrow valley, silty and clayey deposits dominate with some gravel further northwards. Clay is common in the

lower parts of the area, especially between the ridges of bed-rock and till.

5.16.2. Sediment stratigraphy

In the winter of 1976 corings with the Russian sampler were carried out in the northeastern bay of the lake, 50 m from the shore. The water depth at the sampling point is 5.20 m and the sediments down to 7.02 metres below the water surface were not examined.

702 - 773 cm	Layer 4. Fine detritus gyttja, dark-brown. Composition: Ld 4. Lower boundary sharp.
773 - 783 cm	Layer 3. Clay gyttja, light-brown. Composition: Ld 1, As 3. Lower boundary diffuse.
783 - 789 cm	Layer 2. Clayey fine detritus gyttja, brown. Composition: Ld 2, As 2. Lower boundary sharp. A lamina of pure fine detritus gyttja between 7.88 and 7.89 m.
789 - 892 cm	Layer 1. Slightly muddy clay, grey. Composition: As 4, Ld+.

Layers 2 and 3 seem to be partly disturbed. Layer 1 is underlain by varved clay and sand, but the exact thickness of these sediments is not known.

5.16.3. Pollen stratigraphy

The pollen diagram from this site is not published, as the amount of pollen in layer 1 is very low and the stratigraphy of layers 2 and 3 appear disturbed. However, the profile analysed between 8.22 and 7.77 m, with 9 levels analysed, has been divided into four local pollen assemblage zones (Ha1-Ha4). In zone Ha1 the average amount of pollen grains counted is 78. The average count in zone Ha2 is 664 and in zones Ha3 and Ha4 the average count exceeds 1000 pollen grains.

Ha1 822 - 799.5 cm. Characterized by abundant tree pollen, with Pinus and Betula undiff. pollen reaching values between 30 and 40 %. The only significant pollen types, other than tree pollen, are Juniperus and B. nana pollen and secondary pollen grains.

This zone is named the PINUS - BETULA undiff. - BETULA NANA - JUNIPERUS + secondary pollen grains Local Assemblage Zone.

- Ha2 799.5 - 786 cm. Characterized by increasing values of Pinus pollen (between 53 and 67 %) compared with zone Ha1. Empetrum pollen reaches values of more than 3 %. The frequencies of Juniperus and B. nana pollen remain rather high. The values of secondary pollen grains are high in the lower part of the zone.
The zone is named the PINUS - EMPETRUM - BETULA NANA - JUNIPERUS Local Assemblage Zone.
- Ha3 786 - 782.5 cm. Characterized by very high values of tree pollen, mainly Pinus and Betula undiff. pollen.
This zone is named the PINUS - BETULA undiff. Local Assemblage Zone.
- Ha4 782.5 - 777 cm. This zone, the uppermost recorded from Harstorpssjön, is characterized by decreasing values of Betula undiff. pollen and increasing frequencies of Corylus pollen compared with zone Ha3.
The zone is named the PINUS - CORYLUS Local Assemblage Zone.

No radiocarbon analyses have been carried out from Harstorpssjön.

5.16.4. Determination of the isolation level

Layer 1 can clearly be regarded as a Baltic Ice Lake sediment, with low values of Pediastrum colonies (about 2 %) and loss on ignition (3 to 4 %). The values of Isoëtes and Sphagnum spores and secondary pollen grains are high. Compared with layer 1, layer 2 is quite a different sediment, not only visually. It has e.g. high values of Pediastrum colonies (10 %) and loss on ignition (8 to 20 %). The value of secondary pollen grains decreases from 4 to 0.4 % between layers 1 and 2.

Harstorpssjön is concluded to have possibly been isolated from the Baltic Ice Lake between layers 1 and 2. This level corresponds to the PINUS - EMPETRUM - BETULA NANA - JUNIPERUS Local Assemblage

Zone (Ha2).

5.17. Bredsjön (16)

5.17.1. Description of the site

This lake is located 6 km southwest of Ronneby and just north of the coast (Fig. 9). The water level of the lake is situated 12 m a.s.l. Although no evidence of a lowering of the lake has been found in neither old documents nor from the old economic map, the lake has certainly been lowered. The threshold of the basin is situated just south of the lake and consists of bed-rock. This bed-rock threshold has been blasted, and the channel which exists today as an outflow is about 3 m deep. From these observations the original level of the lake is estimated at about 15 m a.s.l.

Bredsjön is surrounded by slightly uneven ground, dominated by bed-rock and till. The basin is situated at the very southern part of the bed-rock plateau mentioned in connection with site 9.

5.17.2. Sediment stratigraphy

In the winter of 1976 coring was carried out with the Russian sampler. One of the cores was pollen analysed and the diagram was so interesting that a 100 mm Livingstone core was taken during the winter of 1977 after fresh investigations with the Russian sampler. The water depth at the coring point, which is situated in the middle of the lake, is 1.7 m. The sediments between 1.7 and 5.00 metres below the water surface were not classified.

500 - 516 cm	Layer 5. Fine detritus gyttja, brown. Composition: Ld 4. Lower boundary diffuse.
516 - 525 cm	Layer 4. Clay gyttja, light-brown. Composition: Ld 2, As 2. Lower boundary sharp.
525 - 690 cm	Layer 3. Slightly muddy clay, grey. Composition: As 4, Ld 0.5. Lower boundary sharp.
690 - 715 cm	Layer 2. Sandy clay, grey. Composition: As 2, Ag 2. Lower boundary diffuse.
715 - 790 cm	Layer 1. Silty clay, reddish grey. Composition: As 3, Ag 1.

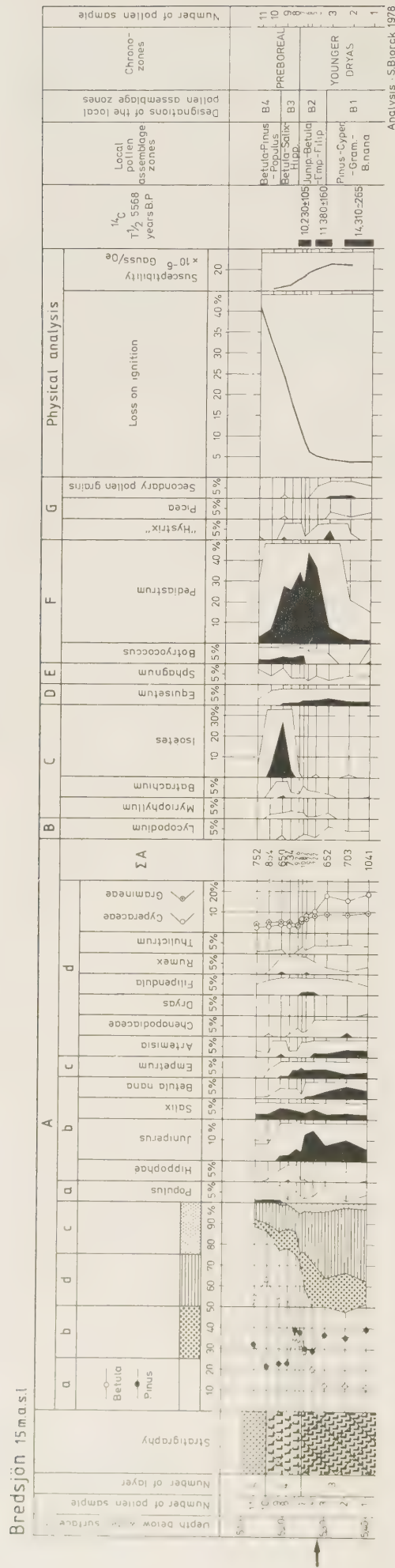


Fig. 35. The pollen diagram from Lake Bredsjön.

The clay of layer 1 appeared to be a varved clay, although somewhat indistinct, with reddish winter laminae. Layers 1 and 2 are not included in the diagram (Fig. 35).

5.17.3. Pollen stratigraphy

Two profiles were pollen analysed from this site. The pollen diagram in Fig. 35 represents the 100 mm Livingstone core, and comprises the sediments between 5.40 and 5.13 metres below the water surface. 11 levels were analysed, and the profile analysed has been divided into four local pollen assemblage zones (B1-B4).

- B1 540 - 528.5 cm. This zone, the lowest recorded in Bred-sjön, is characterized by high values of Pinus pollen, reaching frequencies between 35 and 40 %. Among herb pollen, Cyperaceae (15 to 20 %) and Gramineae pollen (about 10 %) are dominant. In the shrub pollen, Juniperus and B. nana pollen dominate. The values of Juniperus pollen reach almost 10 % but increase even further in zone B2, while B. nana pollen frequencies reach 6 %. This zone is named the PINUS - CYPERACEAE - GRAMINEAE - BETULA NANA Local Assemblage Zone.
- B2 528.5 - 522 cm. Characterized by high values of shrub and dwarf-shrub pollen, and by increasing frequencies of Betula undiff. pollen (from 20 to 35 %) compared with zone B1. Juniperus pollen reaches a maximum value of 15 % and Empetrum pollen attains frequencies between 4 and 5 %. The only significant herb pollen type within this zone is Filipendula pollen, reaching values between 1 and 2 %. The zone is named the JUNIPERUS - BETULA undiff. - EMPETRUM - FILIPENDULA Local Assemblage Zone.
- B3 522 - 517.5 cm. Characterized by high values of Betula undiff. pollen, reaching frequencies of more than 50 %. Salix pollen is rather common (5 %), and Hippophaë pollen is present, reaching a frequency of more than 1 %. This zone is named the BETULA undiff. - SALIX - HIPPOPHAË Local Assemblage Zone.

B4 517.5 - 513 cm. This is the uppermost recorded zone and it is characterized by abundant tree pollen, reaching values of more than 85 % in total. As well as the high values of Pinus and Betula undiff. pollen, Populus pollen values also increase compared with zone B3, reaching frequencies of more than 1 %.

The zone is named the BETULA undiff. - PINUS - POPULUS Local Assemblage Zone.

5.17.4. Radiocarbon analyses

Three samples have been submitted for radiocarbon dating from Bredsjön. The lowermost dated level was between 5.40 and 5.35 metres below the water surface. This level corresponds to zone B1 and the radiocarbon age was $14,310 \pm 265$ B.P. (Lu-1555). The boundary between zones B1 and B2, corresponding to the level 5.30 to 5.26 m, was radiocarbon dated to $11,380 \pm 160$ B.P. (Lu-1556). The uppermost dated level was situated between 5.25 and 5.22 m, which exactly corresponds to the upper half of zone B2. This level had a radiocarbon age of $10,230 \pm 105$ B.P. (Lu-1557). The very high radiocarbon ages will be discussed in Chapter 6.

5.17.5. Determination of the isolation level

The muddy clay of layer 1 is very similar to the slightly muddy clays often found before the isolation, in lakes situated below 30 m a.s.l. This fact, together with some properties of the lowermost part of the profile analysed in Bredsjön (Fig. 35) makes it very plausible that at least samples 1, 2 and 3 were deposited in the Baltic Ice Lake. At these levels the values of Pediastrum colonies and loss on ignition are low, while the frequency of "Hystrix", secondary pollen grains and the magnetic susceptibility are comparatively high. Between samples 3 and 4 rather large changes occur with respect to the above mentioned microfossils and physical properties. As well as the values of "Hystrix" and secondary pollen grains, the value of the magnetic susceptibility decreases between samples 3 and 4. The Pinus pollen value also decreases, while the values of Pediastrum colonies and loss on ignition increase.

Sample 4 is very likely the first isolated level in the profile analysed from Bredsjön, although no visual changes can be seen in layer 1 at this level. The date of the supposed isolation of Bredsjön from the Baltic Ice Lake corresponds to the lower part of zone B2. The boundary between zones B1 and B2 has been radio-carbon dated to 11,380 B.P., but this date will be further discussed in Chapters 6 and 7.

6. ABSOLUTE CHRONOLOGY AND REGIONAL POLLEN STRATIGRAPHY

As the main purpose of this work is to relate Late Weichselian sedimentation and shore line displacement in Blekinge to an absolute chronology, it has been vitally important to establish a reliable chronology. However, out of 27 radiocarbon dated samples, only 16 have been useful in establishing this chronology. Fortunately the rather detailed pollen stratigraphy obtained from the investigation area has been most useful for correlations between radiocarbon dated levels and non-dated pollen profiles. These correlations have also made it possible to correlate the local varve chronology with pollen stratigraphy and thus also with radiocarbon chronology.

6.1. The radiocarbon dates

During the last 10-15 years knowledge of the Late Weichselian chronology in Southern Scandinavia has greatly improved. Since the errors in the geochronological time-scale based on varve measurements (Nilsson 1968) have been revealed (Wenner 1968; Tauber 1970; Fromm 1970; J. Lundqvist 1975), radiocarbon dating of Late Weichselian sediments has become more and more common. Mangerud et al. (1974) and Berglund (1976) have summarized the most important radiocarbon dates in NW Europe from this substage. The chronostratigraphic subdivision of the Late Weichselian by Mangerud et al. (1974) is based on dates of thoroughly studied biostratigraphical profiles through limnic-terrestrial sediments. This substage is divided into four chronozones, which generally speaking agree with the interstadial-stadial-interstadial-stadial development that has been well-known for a long time from this time-period. In Sweden this development has previously been found in Scania (Berglund 1971a), Småland (Bjelm 1976), Västergötland (Digerfeldt and Hilldén in Berglund 1976) and Blekinge (Björck in Berglund 1976), and from the southern Baltic at Bornholm (Usinger 1977). Because of this it has been rather easy to relate the pollen stratigraphy to the Late Weichselian chronozones and thus also to the radiocarbon chronology. These correlations have been very useful in determining the reliability of the radiocarbon dates.

Figs. 36 and 37 show the relation between true (measured) ^{14}C -age and expected ^{14}C -age of samples from four of the investigated

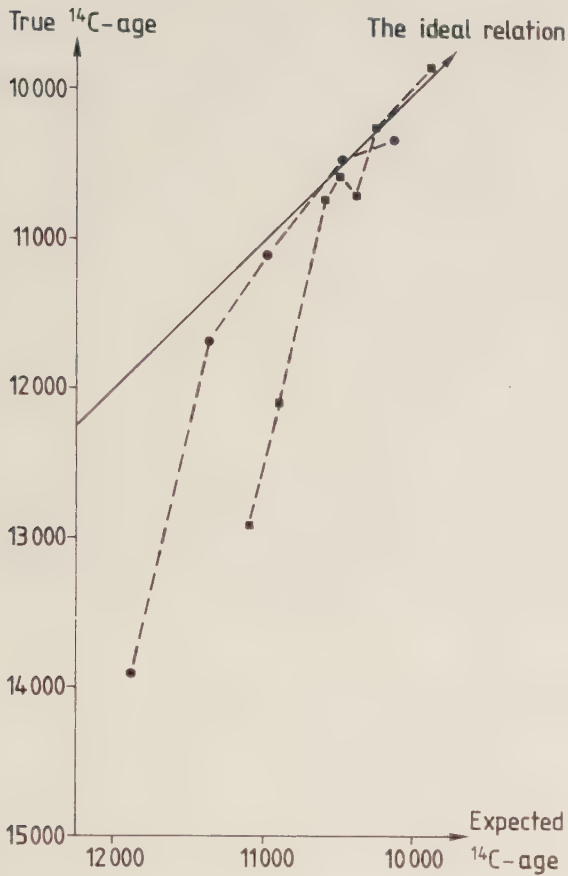


Fig. 36. The relation between true (measured) and expected ^{14}C -age for Lake Kroksjön (●) and Lake Halsjön (■).

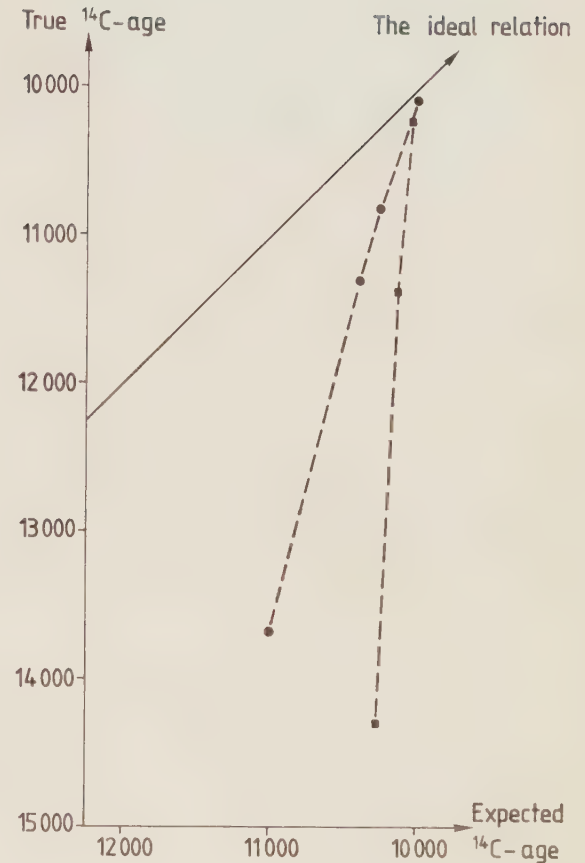


Fig. 37. The relation between true (measured) and expected ^{14}C -age for the previous Lake Paddegölen (●) and Lake Bredsjön (■).

basins. It is clear that the difference between ^{14}C -age and expected ^{14}C -age decreases upwards in the stratigraphy. In all of the four basins this decrease is more or less related to isolation from the Baltic Ice Lake. In the fifth sample from Halsjön II this difference increases temporarily, which will be shown to be of some significance. Apart from the fact that these differences are most pronounced before the isolation of the basins, it is notable that the incorrect radiocarbon ages never exceed 14,300 years B.P., but are very constant between 14,000 and 11,000 years B.P. This probably means that the samples are subject to the same source of error, which also seems to be rather constant. This source of error is possibly at least partly related to the isolation of the basins. According to Mangerud (1972) the importance of the influence of old carbon from glacier ice on marine shells in sea water is negligible. However, the Baltic Ice Lake environment most likely

differed very much from a marine environment just outside the melting ice, as the water in this large ice lake most probably mainly derived from the melting inland ice. The old carbon from the ice was possibly assimilated by organisms living in the hydrosphere as well as in the lithosphere and in the lower parts of the troposphere. The mixture of fresh and old carbon in the Baltic Ice Lake, and in some cases probably including old carbon from redeposited organic material, could explain the too high but rather constant radiocarbon ages obtained from four of the investigated basins, namely Kroksjön, Halsjön, f.d. Paddegölen and Bredsjön. As the fifth sample from Halsjön is thought to date a temporary transgression of the Baltic Ice Lake into this basin, the comparatively high age of this sample supports the idea that the water of the Baltic Ice Lake is one of the sources of errors.

Unfortunately some of the incorrect radiocarbon dates and the not dateable samples were supposed to date the Bölling Chronozone as well as the boundary between the Bölling Chronozone and the Older Dryas Chronozone. However, the remaining important biostratigraphic boundaries of the Late Weichselian have been possible to radiocarbon date with rather good accuracy.

6.2. The regional pollen assemblage zones and their relation to absolute chronology

After establishing local pollen assemblage zones at 14 different sites, a regional division of the pollen stratigraphy has been made on the basis of the local zonation. Originally Berglund's (1966) zonation of the then called Late-Glacial time was used for the local zonation, but as more and more profiles were pollen analysed a more detailed knowledge of the Late Weichselian pollen stratigraphy in Blekinge was obtained. In order to test the zonation carried out by interpreting the vegetational changes and relating these changes to the climatostratigraphy upon which the chronostratigraphy established by Mangerud et al. (1974) is actually based, almost all pollen profiles have been zoned by principal component analysis. Some of these zonations are shown in Figs. 38, 39 and 40. In Figs. 41 and 42 comparisons are made between five basins using principal component analysis. It is clear from these figures that the interpreted division of the pollen stratigraphy coincides very well with the numerical analysis. From

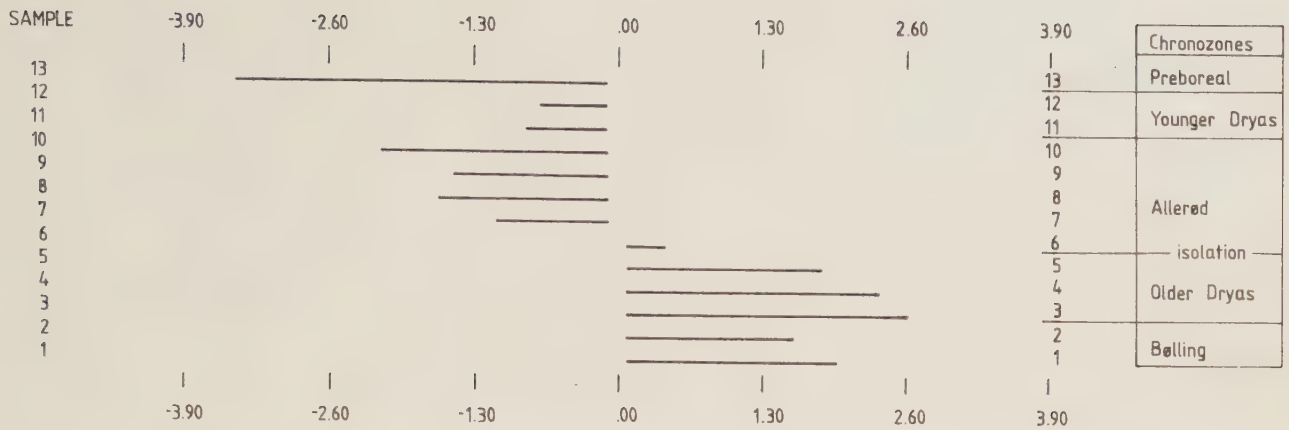


Fig. 38. Stratigraphic plot of sample scores on principal component 1 (33.8 % eigenvalue) from Dönhultagyl (site 6), based on the correlation matrix of the terriphytic spermatophytes and related to the believed local chronostratigraphy.

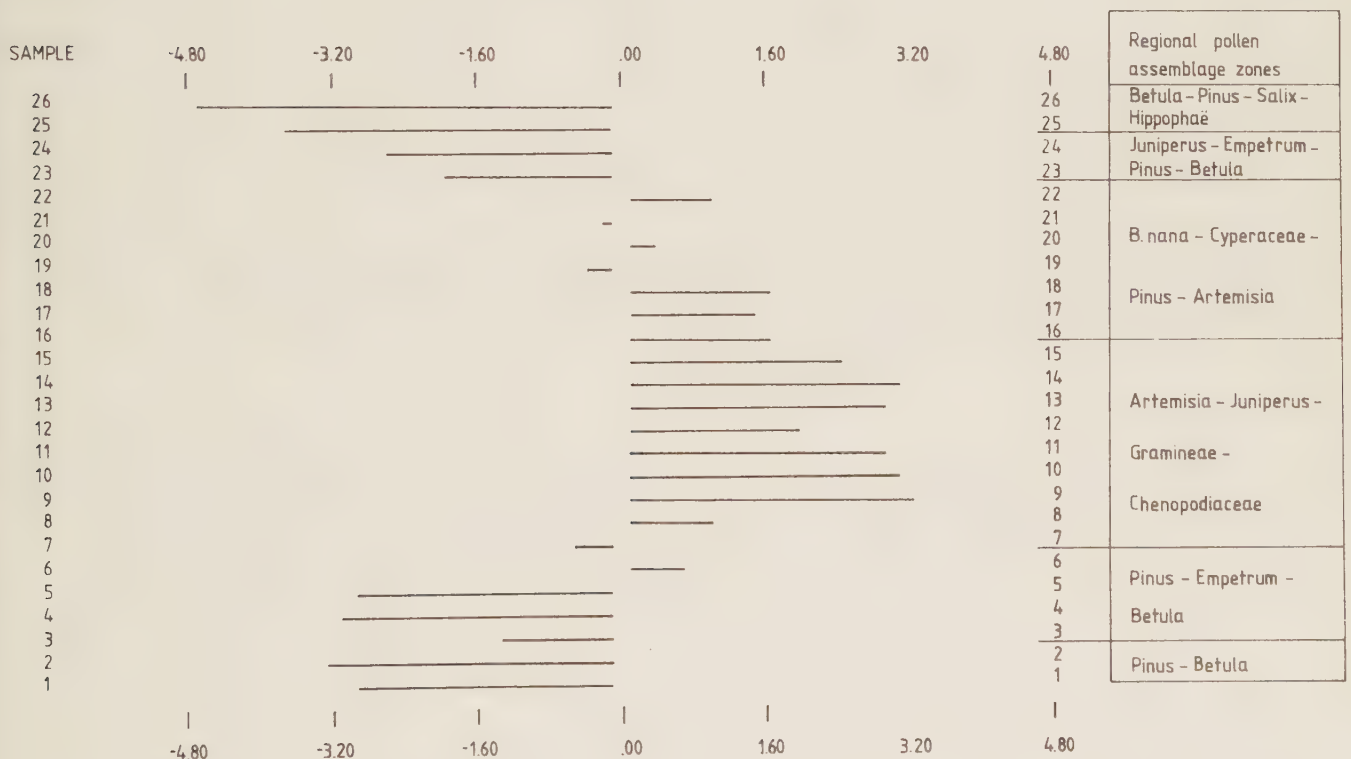


Fig. 39. Stratigraphic plot of sample scores on principal component 1 (36.3 % eigenvalue) based on correlation matrix of terriphytic spermatophytes from Halsjön II (site 10b) related to the regional pollen assemblage zones.

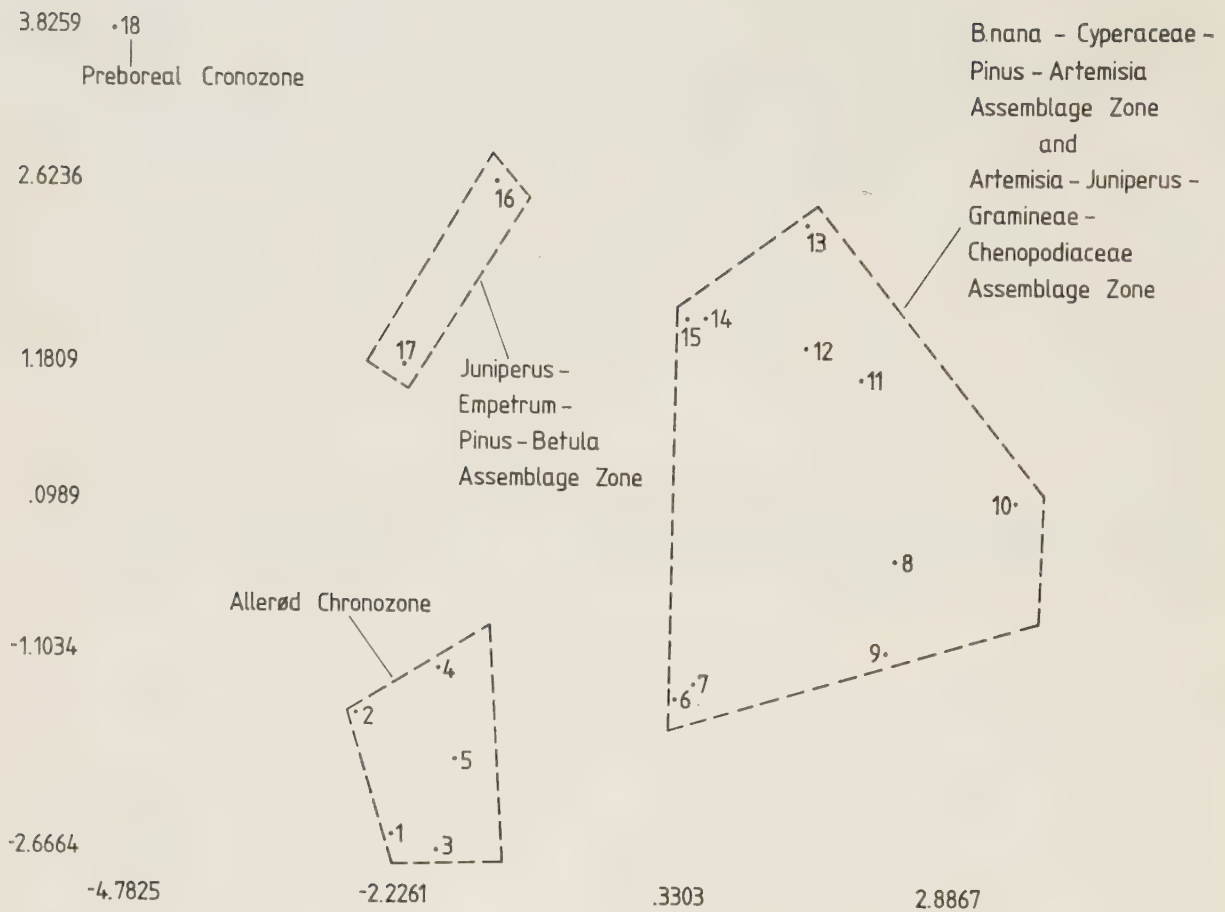


Fig. 40. Plot of samples on first and second principal component (54 % eigenvalue) based on correlation matrix of the terriphytic spermatophytes from f.d. Paddegölen, related to chronostratigraphy or regional pollen stratigraphy.

the comparisons between the basins it is clear that the zonation is relatively regional, and that, generally speaking, one finds the same vegetational development in basins situated far from each other. This provides good support for the possibility of establishing regional pollen assemblage zones within the investigation area.

6.2.1. Description of the regional pollen assemblage zones

The division of the pollen diagrams into local assemblage zones is summarized in Figs. 43a and 43b, and the regional pollen assemblage zones, which represent the synthesis of these local zones, have been named and defined as follows, starting with the lowermost zone.

1. BETULA undiff. - ARTEMISIA - BETULA NANA - GRAMINEAE Regional Assemblage Zone

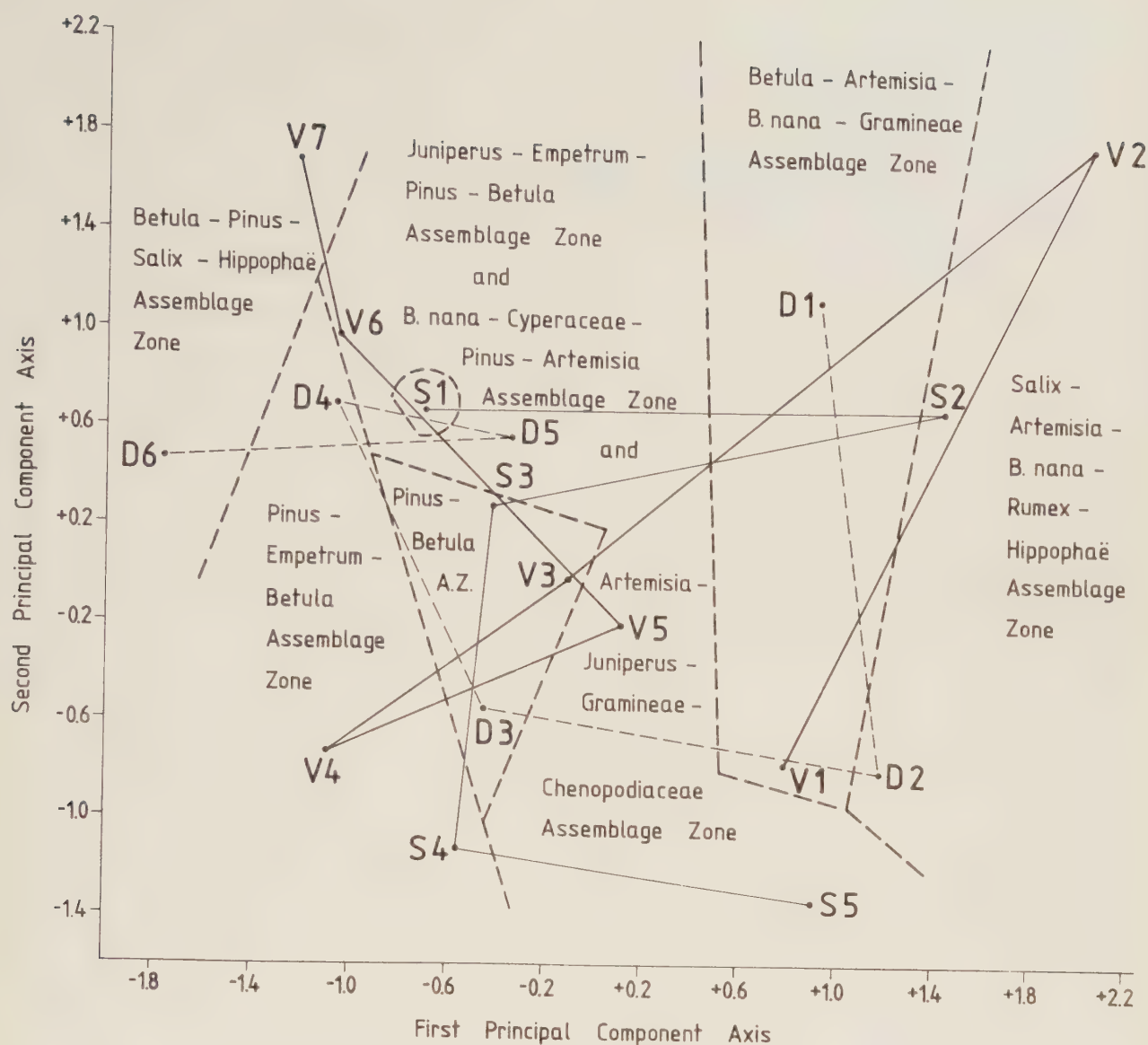


Fig. 41. Comparison of Vitavattsgyl (V), Sännen (S) and Dönhultagyl (D) using principal components analysis. The mean scores of the local pollen assemblage zones are plotted on the first and second principal components, related to the regional pollen assemblage zones (Fig. 43a), and are joined up in stratigraphic order.

Occurrence: The local zones that resemble this regional zone the most are zones S1 (Sännen), L01 (Logylet) and L1 (Lilla sjön), but zones V1, K1 and D1 are also included in this regional assemblage zone.

Description: Betula undiff. pollen is dominant, with values usually between 25 and 50 %. Artemisia and Gramineae pollen dominate among the herb pollen types, with frequencies usually between 5 and 10 %. B. nana pollen is very common and sometimes characterizes the zone together with Betula undiff. pollen. It attains values between 10 and 20 %. Generally speaking, herb pollen values are

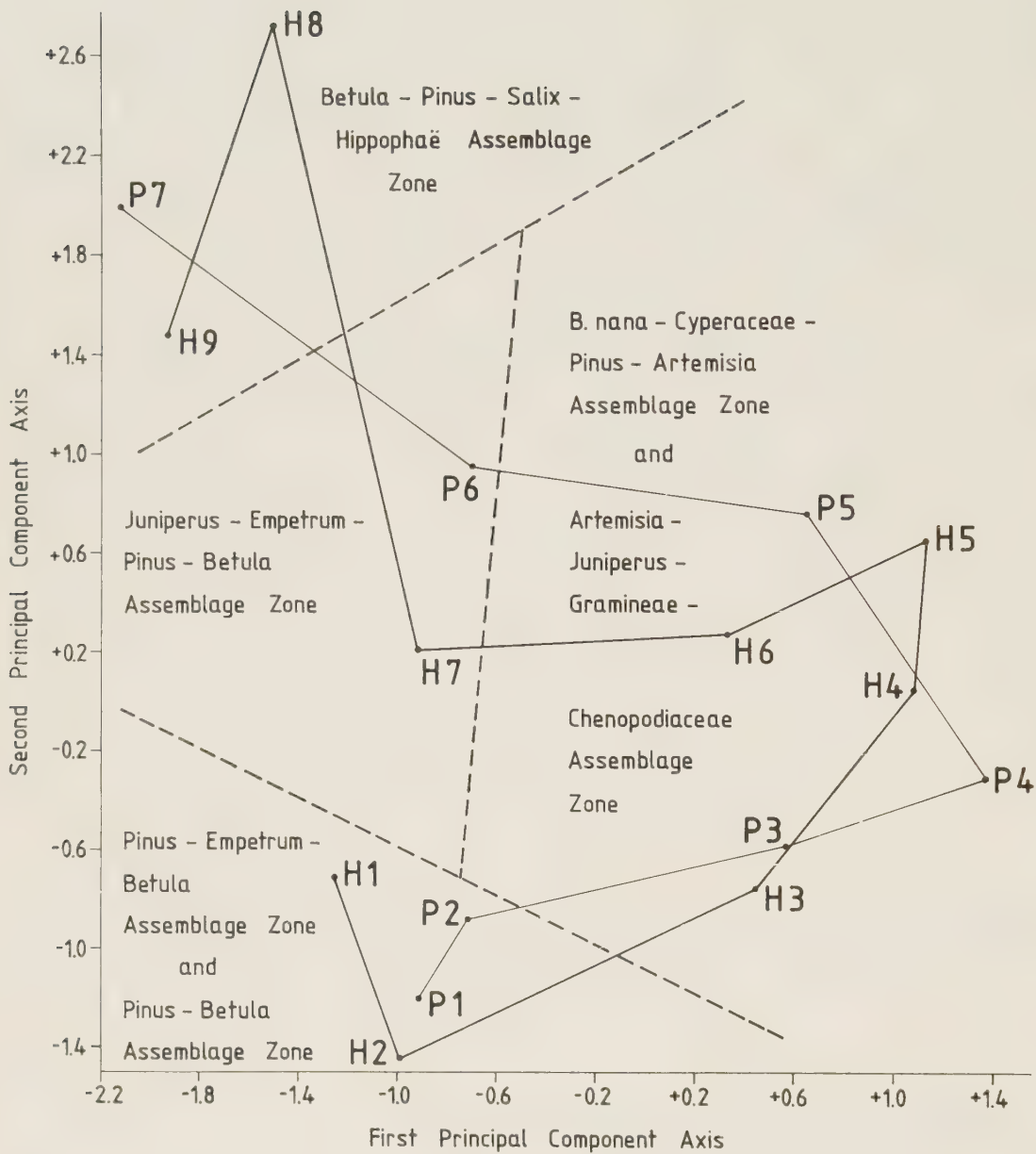


Fig. 42. Comparison of Halsjön II (H) and f.d. Paddegölen (P) using principal component analysis. The mean scores of the local pollen assemblage zones are plotted on the first and second principal components, related to the regional pollen assemblage zones (Fig. 43b), and are joined up in stratigraphic order.

rather low, while the tree pollen values are comparatively high. The shrub pollen frequencies vary, but are usually low, and the dwarf-shrub pollen values are negligible.

Contacts: The upper boundary is placed where the values of tree pollen decrease and the frequencies of herb pollen increase. This boundary is also usually characterized by increasing values of Salix and Artemisia pollen and is normally drawn before the first

occurrence of Hippophaë pollen.

Age and extent: Unfortunately no radiocarbon dates have been obtained from this zone in Blekinge, but as it is correlated with the Bölling Chronozone the upper boundary is placed at 12,000 radiocarbon years B.P. Mangerud et al. (1974) and Berglund (1976) have shown that this is the most appropriate upper boundary for this chronozone in NW Europe. Pennington (1977) correlates the Rumex - Empetrum - Juniperus pollen assemblage zone in Northern Scotland with the Bölling Chronozone and the date of the upper boundary of this pollen assemblage zone is 12,000 B.P. At Kroksjön zone K1 is correlated with this regional zone, but as only the upper part of the varved clay has been pollen analysed, it is not possible to determine with certainty whether this pollen assemblage characterizes the whole section of the varved clay or not. However, if this is the case the lower boundary of this regional pollen assemblage zone is dated to 12,000 radiocarbon years plus at least 300 varve years.

Remarks: This zone is associated with sediments of distinctive lithology, being clays or silty clays of low organic content (less than 3 % loss on ignition). At three sites (2, 3 and 5) the lower part of the zone consists of varved clay. The zone is usually characterized by rather high values of pollen types interpreted as being secondary pollen grains as e.g. Corylus, Alnus and Quercus.

2. SALIX - ARTEMISIA - BETULA NANA - RUMEX - HIPPOPHAË Regional Assemblage Zone

Occurrence: The local zones S2 (Sännen), Lo2 (Logylet) and Å1 (Årsjön) resemble this regional zone the most, but it is also correlated with the local zones V2, K2, D2 and L2.

Description: Herb pollen is characteristic of this zone, reaching frequencies between 30 and 40 %. Typical herb pollen types are Artemisia (between 5 and 10 %) and Rumex (around 5 %) pollen. The zone is usually also characterized by high shrub pollen values, and among these Salix pollen dominates, attaining frequencies between 10 and 15 %. However, B. nana and Hippophaë pollen are also often characteristic of this zone. The tree pollen values often reach a minimum in this zone, and the dwarf-shrub frequencies are negligible.

Contacts: The lower boundary is placed where the herb and shrub pollen values increase markedly at the expense of the tree pollen

Regional pollen assemblage zones	Vitavattsgyl 18 km	Sannen 17 km	Logylet I (III) 14 km	Årsjön 19 km	Kroksjön 12 km	Dönkhultagyl 9 km	Lilla sjön 6.5 km	Galtsjön 6 km	Chrono - zones	¹⁴ C - years before present
	Local pollen assemblage zones	Local pollen assemblage zones	Local pollen assemblage zones	Local pollen assemblage zones	Local pollen assemblage zones	Local pollen assemblage zones	Local pollen assemblage zones	Local pollen assemblage zones		
8	Betula - Pinus		22 Lo 8		23 K 8	13 D 6		18 G 7	PREBOREAL	
7	Juniperus - Empetrum - Pinus - Betula	21 Lo 7	Juniperus - Empetrum - Cyper - Gram.		22 K 7			16-17 G 6		-10 000
6	B. nana - Cyperaceae - Pinus - Artemisia	19-20 Lo 6	B. nana - Cyperaceae - Artemisia - Juniperus		20-21 K 6	11-12		13-15 G 5		-10 200
5	Artemisia - Juniperus - Gramineae - Chenopodiaceae	17-18 Lo 5	Artemisia - Salix - Gramineae - Juniperus		16-19 K 5	D 5	15-18	6-10 G 3	YOUNGER DRYAS	-10 500
4	Pinus - Empetrum - Betula	11-13 S 4	Pinus - Betula - Empetrum		13-15 K 4	10	12-14	3-5 G 2		-11 000
3	Pinus - Betula	9-10 S 3	Pinus - Betula - Juniperus		10-12 K 3	6-9 D 3	6-11	1-2 G 1	ALLERØD	-11 400
2	Salix - Artemisia - B. nana - Rumex - Hippophäe	6-8 S 2	Salix - B. nana - Cyper - Artem. - Rumex - Hipp.		7-9 K 2	3-5 D 2	4-5			-11 800
1	Betula - Artemisia - B. nana - Gramineae	1-5 S 1	Betula - Artemisia + sec. pollen		1-6 K 1	1-2 D 1	1-3		OLDER DRYAS	-12 000
									BOLLING	

Fig. 43a. The local pollen assemblage zones of sites 1-6 and 8-9 related to chronostratigraphy and the regional pollen assemblage zones.

frequencies. The first occurrence of Hippophaë pollen is also a good indicator of the lower boundary. The upper boundary is characterized by a sudden increase in tree pollen values and usually also the disappearance of Dryas pollen.

Age and extent: The upper boundary of this zone is correlated to the upper boundary of Berglund's pollen zone Older Dryas from Lösensjön (1966 and 1976) which is correlated to the upper boundary of the Older Dryas Chronozone and has an age of $11,740 \pm 170$ years B.P. The extent of this zone is believed to be 200 radiocarbon years thus lasting from 12,000 to 11,800 radiocarbon years B.P., which means that it is believed to be synchronous with the Older Dryas Chronozone (Mangerud et al., 1974).

Remarks: Characterized by silt and clay with low organic content (usually less than 3 % loss on ignition). Usually no distinct lithologic change occurs between this zone and zone 1.

3. PINUS - BETULA undiff. Regional Assemblage Zone

Occurrence: The local zones Lo3 (Logylet) and K3 (Kroksjön) resemble this regional zone the most, but it is also correlated with the local zones V3, S3, Å2, D3, L3, G1, HI1 and HII1.

Description: Characterized by abundant tree pollen with Pinus pollen as the dominant, usually reaching values between 30 and 40 %. The Betula undiff. pollen values are normally slightly lower than the Pinus pollen values. The herb and shrub pollen frequencies are low and the dwarf-shrub pollen values are negligible.

Contacts: The lower boundary is drawn where the tree pollen values increase markedly and the herb pollen values decrease. The upper boundary is placed where Empetrum pollen values exceed 1 % or become significant for the pollen assemblage.

Age and extent: The upper boundary of this zone is radiocarbon dated to $11,430 \pm 140$ B.P. at Logylet, and a radiocarbon date from Lake Trummen in Småland (Digerfeldt and Berglund, in Berglund 1976) dates a level slightly above this boundary to $11,390 \pm 155$ B.P. The middle part of this zone is radiocarbon dated to $11,810 \pm 190$ B.P. at Logylet, but the large errors quoted should be noted. The extent of this zone is thought to be 400 radiocarbon years, lasting from 11,800 to 11,400 B.P., and thus being synchronous with the lower half of the Alleröd Chronozone (Mangerud et al. 1974).

Remarks: This zone is usually characterized by a sudden increase in organic material, with clay or muddy clay as the most common sediment types.

4. PINUS - EMPETRUM - BETULA undiff. Regional Assemblage Zone

Occurrence: The local zones V4 (Vitavattsgyl), S4 (Sännen), Lo4 (Logylet) and L4 (Lilla sjön) resemble this regional zone the most, but it is also correlated with local zones Å3, K4, D4, G2, HI2, HII2, P1, P2, T1 and T2.

Description: Compared with zone 3 the major difference is the increasing values of Empetrum pollen, at some sites attaining frequencies of more than 10 %. Tree pollen is still dominant, and herb and shrub pollen values are low.

Contacts: The lower boundary is placed where Empetrum pollen increases markedly, while the upper boundary is drawn where tree pollen values start to decrease, and where herb pollen frequencies, especially Artemisia pollen, start to increase. This usually happens slightly above the Empetrum peak.

Subdivision: This zone can be subdivided into two sub-zones at f.d. Paddegölen (P1 and P2) and at f.d. Togölen (T1 and T2).

Age and extent: The upper boundary of this zone is radiocarbon dated at three sites, namely at Logylet ($11,040 \pm 150$ B.P.), Kroksjön ($11,000 \pm 130$ B.P.) and Galtsjön ($11,000 \pm 175$ B.P.).

These dates show that the extent of this zone is about 400 radiocarbon years. The zone is placed between 11,400 and 11,000 B.P., and is thus synchronous with the upper half of the Alleröd Chronozone.

Remarks: The sediments of this zone are usually characterized by an increase in the organic content, usually with a maximum in loss on ignition values at the very end of the zone.

5. ARTEMISIA - JUNIPERUS - GRAMINEAE - CHENOPODIACEAE Regional Assemblage Zone

Occurrence: The local zones S5 (Sännen), K5 (Kroksjön), L5 (Lilla sjön) and HI3 (Halsjön I) resemble this regional zone the most, but the local zones V5, Lo5, Å4, D5, G3, HII3, HII4, HII5, P3, N1, T3 and T4 are wholly or partially correlated with this regional zone.

Description: High values of herb pollen, usually exceeding 30 %, occur, with Artemisia (attaining values of 10-15 %), Gramineae (attaining values between 10 and 15 %) and Chenopodiaceae pollen as the most significant pollen types. Shrub pollen is also rather common, with Juniperus pollen as the dominant pollen type reaching values of almost 10 % at some sites. Tree and dwarf-shrub pollen frequencies are low.

Contacts: The lower boundary is characterized by markedly increasing values of Artemisia pollen and rapidly decreasing frequencies of tree and Empetrum pollen. The upper boundary is usually drawn just above the pronounced peak in the Artemisia pollen curve.

Subdivision: At Halsjön II this zone can be subdivided into three sub-zones (HII3, HII4 and HII5) and at f.d. Togölen into two sub-zones (T3 and T4).

Age and extent: The upper boundary has been successfully radiocarbon dated at three sites. At Kroksjön it was dated to $10,460 \pm 95$ B.P., at Galtsjön $10,470 \pm 110$ B.P. and at Halsjön II $10,560 \pm 100$ B.P. These dates show that this zone lasted between 11,000 and 10,500 B.P., and is thus synchronous with the lower half of the Younger Dryas Chronozone (Mangerud et al. 1974).

Remarks: This zone is characterized by decreasing loss on ignition values.

6. BETULA NANA - CYPERACEAE - PINUS - ARTEMISIA Regional Assemblage Zone

Occurrence: The local zones Lo6 (Logylet) and Get1 (Getsjön) resemble this regional zone the most, but the local zones V5, K6, D5, G4, HI4, HII6, P4, P5, N2, N3, T5, T6 and B6 are wholly or partially correlated with this regional zone.

Description: This zone is usually characterized by the absence of any completely dominating pollen type. It is the oldest zone with a moderate balance between tree, shrub and herb pollen types. Among the shrub pollen B. nana pollen dominates, attaining values of more than 10 %. Cyperaceae (with values between 10 and 20 %) and Artemisia (with values of 10-15 %) pollen dominate the herb pollen, while Pinus pollen is the most common tree pollen type. Dwarf-shrub pollen start to increase in the upper part of the zone.

Contacts: The lower boundary is characterized by decreasing values of herb pollen (especially Artemisia pollen) and increasing values of tree pollen. The upper boundary is usually drawn where Juniperus and Empetrum pollen values start to increase markedly.

Subdivision: This zone can be subdivided into two sub-zones at f.d. Paddegölen (P4 and P5), Norrsjön (N2 and N3) and at f.d. Togölen (T5 and T6).

Age and extent: The upper part of this zone is radiocarbon dated at Halsjön II where the age is $10,260 \pm 95$ B.P. At Kroksjön the upper boundary of this zone has a radiocarbon age of $10,330 \pm 95$

B.P., and at Lake Trummen in Småland (Digerfeldt and Berglund, in Berglund 1976) the upper part of the Artemisia - Gramineae - Cyperaceae - Juniperus Assemblage Zone (corresponding to the regional zones 5 and 6 in this work) has a radiocarbon age of $10,300 \pm 110$ B.P. The upper boundary of zone 6 is placed at 10,200 B.P., which means that this zone lasted from 10,500 to 10,200 B.P., and the extent of this zone is thus 300 radiocarbon years.

Remarks: This zone is characterized by slowly increasing loss on ignition values.

7. JUNIPERUS - EMPETRUM - PINUS - BETULA undiff. Regional Assemblage Zone

Occurrence: This regional zone is usually rather uniform at all sites investigated. The local zones V6, Lo7, K7, G5, HI5, HII7, P6, N4, T7, Get2, B2 and the upper part of zone D5 are correlated with this regional zone.

Description: It is characterized by high frequencies of Juniperus and Empetrum pollen, attaining values between 10 and 15 %. Tree pollen values are high, with Pinus pollen usually the dominant pollen type. A marked decrease in herb pollen values is also significant in this zone, with the decrease in Artemisia pollen values as the most distinct feature. However, Cyperaceae pollen values usually increase in this zone.

Contacts: The lower boundary of this zone is usually drawn slightly below the Empetrum peak, which often coincides with the Juniperus peak. The upper boundary is placed just below the level where the Betula undiff. pollen values rapidly increase and the Pinus pollen values decrease. This means that the upper boundary is usually drawn where the Betula undiff. and Pinus pollen values are about the same.

Age and extent: The upper boundary of this zone has a radiocarbon age of $10,020 \pm 120$ B.P. at Galtsjön. At f.d. Paddegölen and at Galtsjön the upper part of this zone has a radiocarbon age of $10,100 \pm 95$ B.P. and $10,050 \pm 100$ B.P. respectively. The middle part of this zone is radiocarbon dated to $10,230 \pm 105$ B.P. at Bredsjön, but the other dates from this site have been shown to be much too old (Fig. 37), which could mean that this date is also at least slightly too old. The radiocarbon age of the upper boundary of this regional assemblage zone is estimated at 10,000 B.P., which means that the regional zones 6 and 7 are correlated with the upper half of the Younger Dryas Chronozone (Mangerud et al. 1974).

Zone 7 corresponds to the Younger Dryas-Preboreal transition zone (DR3-PB) described by Iversen (1954) and Berglund (1966). The upper boundary was dated at Hallarums mosse to $10,000 \pm 170$ B.P. (Berglund 1966).

Remarks: This zone is characterized by a very sudden increase in the loss on ignition values.

8. BETULA - PINUS Regional Assemblage Zone

Occurrence: This zone is very uniform within the whole investigation area, and the local zones V7, Lo8, K8, D6, G6, G7, HI6, HII8, HII9, P7, N5, N6, T8, Get3, B3 and B4 are correlated with at least parts of this regional zone.

Description: It is characterized by abundant tree pollen. Betula undiff. pollen dominates, attaining values between 40 and 70 %. Other characteristic pollen types are Salix (reaching values of more than 5 %) and Hippophaë pollen. Herb pollen values are extremely low, while shrub pollen frequencies do not decrease to the same extent.

Contacts: The lower boundary is drawn where the Betula undiff. pollen values just start to increase rapidly. This usually coincides with decreasing frequencies of Pinus, Juniperus and Empetrum pollen as well as with increasing Hippophaë pollen values. The upper boundary is not defined in this zone.

Subdivision: This zone is subdivided into two sub-zones at Galtsjön (G6 and G7), Halsjön II (HII8 and HII9), Norrsjön (N5 and N6) and at Bredsjön (B3 and B4).

Age and extent: This zone is correlated with the lower part of the Preboreal Chronozone (Mangerud et al. 1974) and is described from Blekinge by Birks and Berglund (1979).

7. WATER LEVEL CHANGES IN THE BALTIC ICE LAKE

7.1. Isolation indicators

In chapter 5 the isolation level of each basin investigated was fixed. In this section I shall deal with the theory behind these interpretations. As e.g. Berglund (1966) and Ingmar (1973) pointed out, an isolation of a lake is usually immediately followed by a maximum in the alga productivity. According to Berglund (1966, p. 79) there are mainly four plausible causes for this maximum, with special reference to the 'Late-Glacial'.

- 1/ Slight competition from other plant communities favours an expansion. The habitats were virgin in Late-glacial lakes (competition low in macro- as well as in micro-vegetation), especially in recently isolated lakes.
- 2/ A good supply of nutrients.
- 3/ Suddenly rising temperature favours the organic production - the rate of metabolism is due to the temperature.
- 4/ Improvement of the light climate in a lake, e.g. a development from a clayey water to a transparent.

According to Berglund (1966) a combination of these factors may cause an increase in alga productivity. Apart from the lithological change in the sediment, Berglund's main isolation indicators are Pediastrum and Botryococcus. However, this investigation shows the occurrence of nine different isolation indicators in the basins investigated. In Fig. 44 the change in percentages of isolation indicators between the last non-isolated level and the first isolated level is calculated. However, it is important to point out that the isolation could, in some cases, have occurred over quite a long time-span. This means that the isolation phase, in those cases, is not represented by two levels only, but perhaps by three or four levels, although it is shown neither in Fig. 44 nor in the pollen diagrams. This may, in some cases, explain why the values of the isolation indicators do not change as expected. The expected change perhaps occurred previous to the level interpreted as the last not isolated. It is however, clear from Fig. 44 that out of 157 possibilities only 23 have changed in the wrong direction.

INDICATORS	Pinus	Sec. pollen	Isoëtes	Sphagnum	Hystrix	Botryoc.	Pediastrum	Loss on ign.	Susceptib.
BASINS .									
Sännen	-16.0	-92.5	-91.7	-96.5	+∞	-50.0	+1419.4	+20.8	—
Logylet	+26.4	-85.1	-60.0	-16.7	+25.0	-25.0	+708.6	+19.0	-1.8
Kroksjön	-12.4	-68.9	-66.7	-49.2	-100	-11.5	+3828.6	+15.0	-62.4
Dönhultagyl	-26.7	-41.0	-100	-95.7	±0	+833.3	+∞	+123.5	—
Lilla sjön	-48.6	+8.3	-100	-57.1	-90.0	-60.0	+136.2	+194.7	—
Galtsjön	+7.0	-48.6	-9.1	-55.1	-100	±0	+162.5	+14.8	±0
Isolation no. 1	-23.1	-43.1	-47.9	-47.4	±0	-26.7	+58.0	+5.3	-19.7
Halsjön I	2	-51.7	-40.0	-34.8	-50.0	+122.7	+53.3	+40.0	-25.9
3	-17.8	-17.1	-77.8	-78.9	±0	+107.7	+104.1	+24.1	-58.5
Isolation no. 1	+17.6	-54.0	-47.1	±0	+118.2	+∞	+∞	-13.0	-2.5
Halsjön II	2	-18.6	-48.9	-56.8	-100	+140.0	+9.2	+22.7	+23.1
3	-23.1	-73.3	-75.0	-76.5	-100	+800.0	+24.7	+89.3	-50.0
F.d. Paddegölen	-1.0	-60.0	±0	+∞	±0	+114.3	+55.9	+91.3	-71.0
Norr sjön	-30.5	-54.4	-100	-75.0	+∞	-50.0	+∞	+20.7	—
Togölen	-41.0	+5.3	±0	±0	-100	+∞	-91.4	+54.5	-59.8
Get sjön	-11.4	-35.9	-100	-60.0	+600	-66.7	+68.6	+22.2	-45.8
Harstorpsjön	-4.0	-89.2	-25.0	-33.3	±0	+200.0	+600.0	+120.6	—
Bredsjön	-20.9	-40.0	+∞	+100.0	-82.5	+60.0	+398.6	+18.6	-21.6

Fig. 44. Isolation indicators and the change in % between the sample before the proposed isolation level and the sample just after the isolation. - means that the indicator values decrease after the isolation and + means that the indicator values increase after the proposed isolation. The figures underlined show indicators which have changed in the wrong direction.

7.1.1. Pinus

It is obvious from Fig. 44 that the values of Pinus pollen usually decrease at the proposed isolation levels. This decrease is thought to be caused by a restriction of long-distance transported material from the Baltic Ice Lake, when the basins were isolated. It is known that Pinus pollen has the ability to be spread long distances by air as well as by water currents. The decrease is also related to a reduction in the wave-washing of the surrounding shores when a former bay of a large ice lake becomes a small lake. This wave reduction decreases the in-put of redeposited pollen-grains from the surrounding soils. These two main causes mean that a certain part of the Pinus pollen before the isolation should be regarded as secondary pollen-grains.

7.1.2. Secondary pollen-grains

With two exceptions, the values of secondary pollen-grains decrease markedly at the isolation level (Fig. 44). The designation "secondary pollen-grains" includes the following pollen types: Alnus, Ulmus, Tilia, Quercus, Carpinus, Picea and Corylus. Apart from being typical interglacial tree pollen types, the fact that they are always more or less ruptured has led me to assign them to this group. The richest source in secondary pollen grains is probably the till and the glaciogenic sediments surrounding the lakes. When the basins were isolated the wave-washing of the shores decreased and thus also the outwash of old organic material. Possibly also the reduction of long-distance transported material after the isolation was of some importance for the characteristically drastic change in the value of secondary pollen-grains at the isolation.

7.1.3. Isoëtes

It is clear from Fig. 44 that Isoëtes is a good isolation indicator, and that it usually decreases markedly just after the isolation. The causes for this decrease are the same as were pointed out for secondary pollen-grains.

7.1.4. Sphagnum

Fig. 44 shows that Sphagnum is as good as isolation indicator as Isoëtes, and the reason for its decrease at the isolation is thought to be the same as for secondary pollen-grains.

7.1.5. "Hystrix"

"Hystrix" is not as good as isolation indicator as e.g. Sphagnum and Isoëtes (Fig. 44). This is probably due to the relatively low amount of "Hystrix" found in the sediments. The reason for its decrease at the isolation is probably the same as for secondary pollen-grains.

7.1.6. Botryococcus

This green alga has been shown to be the least significant isolation indicator (Fig. 44). At about 2/3 of the isolation levels the values of this alga increased. The reason for this increase is probably a combination of some of the factors that Berglund (1966) mentioned, which were described above.

7.1.7. Pediastrum

It is obvious from Fig. 44 that Pediastrum is a very good isolation indicator. Usually it increases markedly just after the isolation and the reason for this, often very sudden, increase is supposed to be a combination of some of the factors mentioned by Berglund.

7.1.8. Organic material

This is also a good isolation indicator (Fig. 44). With the exception of one case, the values for organic material always increases. The reasons for this are probably a function of the factors mentioned by Berglund, an increasing input of organic material from the surroundings, as no material can leave the basin after the isolation, and a decreasing rate of minerogenic sedimentation when the basin becomes isolated from the Baltic Ice Lake.

7.1.9. Magnetic susceptibility

This has been shown to be a good isolation indicator (Fig. 44). The values for susceptibility usually decrease very markedly during the isolation. It is shown in Figs. 14 and 20 that these values seem to be related to the amount of the heavy mineral magnetite. This relation makes it possible to explain the decreasing susceptibility values immediately after the isolation as a function of magnetite sedimentation. The period when the basins were in contact with the Baltic Ice Lake was possibly characterized by a relatively intense period of wave-washing of the shores. As the water level during this stage changed all the time, a large shore surface must have been wave-washed. During this period of wave-erosion the magnetite particles probably became over-represented, as they sediment quicker than other particles of the same size, due to their weight (Ljunggren and Sundborg 1968). However, after the basins became isolated the environment was relatively calm and no new shores were washed by the waves. This interpretation of the changes in the susceptibility values is supported by the fact that the highest susceptibility values are found in basins at higher altitudes, with a comparatively dense archipelago with "fresh" soils during the pre-isolation phase. Oldfield et al. (1978) have also linked susceptibility variations to erosion into lakes of inorganic material from the drainage basins.

7.1.10. Diatoms

The diatoms have not been used for defining any of the isolation levels. This is because the only changes in the diatom flora appearing at the isolation level are of a quantitative nature. At f.d. Paddegölen and Halsjön they almost disappear after the isolation, while the number of values increases after the isolation of Kroksjön. The diatom composition only shows that the sediments analysed were deposited in a fresh water environment.

7.2. Dating of the isolation levels and interpretation of water level changes in the basins investigated

As the Late Weichselian pollen stratigraphy of the basins

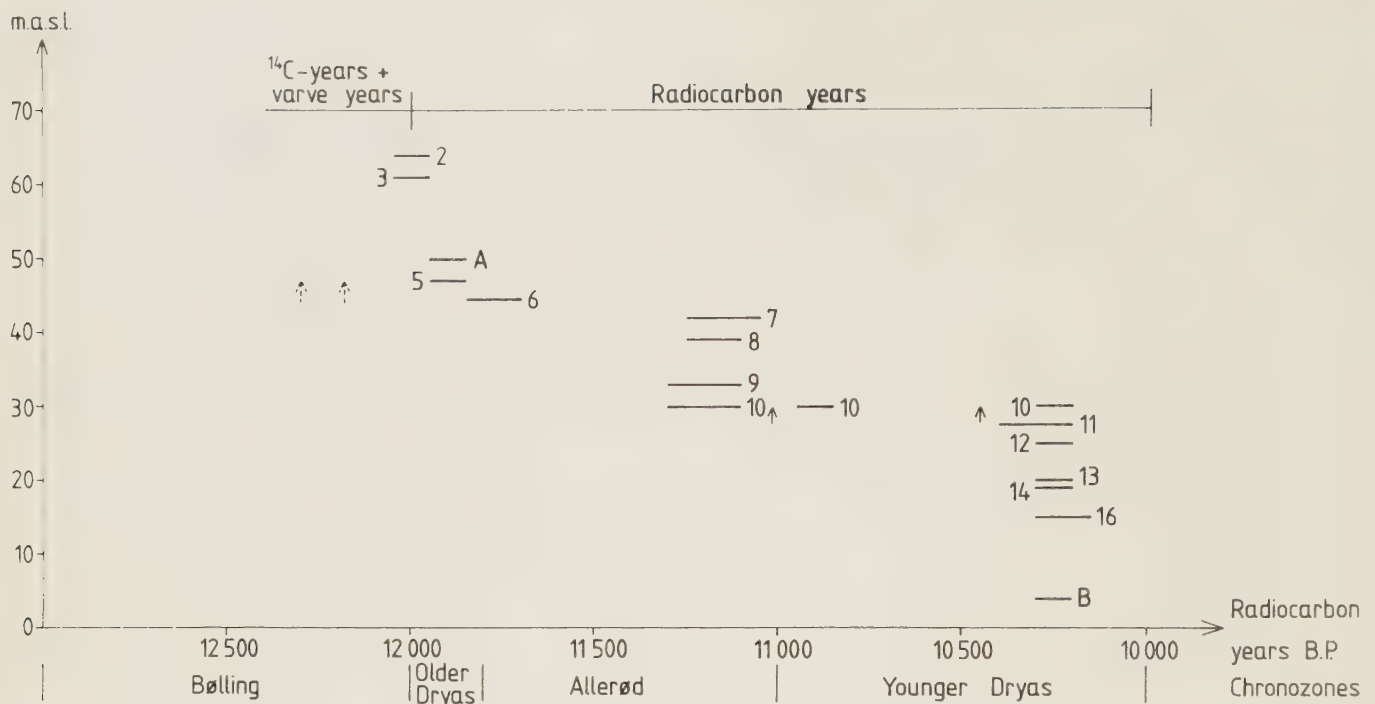


Fig. 45. The proposed isolation levels of the different basins, related to the chronology. The arrows show the postulated transgressions, while the dotted arrows show the alternative dates of the initial transgression. Figures and letters refer to the designations of the basins in Chapter 7.2.

investigated has been carefully zoned and related to the radiocarbon chronology, it has been possible to date the proposed isolation levels with a high degree of accuracy. Two of Berglund's (1966) sites are used to complement my own. The sites are described from the highest basin down to the lowest situated. Except where otherwise stated, the date of the isolation refers to conventional radiocarbon years before present (B.P.). In Fig. 45 the isolation levels are related to the radiocarbon chronology.

7.2.1. Vitavattsgyl 71 m a.s.l. (1)

Zone VI is correlated with the Bölling Chronozone, and there are no indications that the basin was ever influenced by the Baltic Ice Lake, which shows that Vitavattsgyl is most likely situated above the highest shore line.

7.2.2. Sannen 64 m a.s.l. (2)

According to Ringberg (1971) this basin is situated just some metre below the highest shore line. The isolation is thought to have taken place at the boundary between zones S1 and S2, which is correlated with an age of 12,000 B.P. This means that the isolation of Sannen is dated to 12,050 - 11,950 B.P. (Fig. 45), which means that the highest shore line is just slightly older, as it should be situated between 71 and 64 m a.s.l. according to this investigation and 65 - 67 m a.s.l. according to Ringberg (1971).

7.2.3. Logylet 61 m a.s.l. (3)

The isolation level of this basin is determined to the boundary between zones Lo1 and Lo2, which coincides with the boundary between the Bölling and the Older Dryas Chronozones dated to 12,000 B.P. The isolation of this basin is thought to have taken place some time between 12,050 and 11,950 B.P. (Fig. 45). The lower part of zone Lo1 is correlated with layer 1, which is varved clay consisting of about 100 varves. This means that the basin was deglaciated more than 100 years before the isolation from the Baltic Ice Lake. It also means that the regression gradient must have been very low if the highest shore line was synchronous with the deglaciation. The increasing values of magnetite at the end of the varved clay section (Fig. 14) could be explained by a water level change in the basin, but the consequence of such an interpretation will be discussed further on.

7.2.4. Årsjön 58 m a.s.l. (4)

Although this basin is situated below the highest shore line, it does not seem to have been influenced by the Baltic Ice Lake. This can be explained either by the fact that dead-ice occupied this depression during and for a short time after the development of the highest shore line, or that the basin, as it is located in a river valley, was influenced by a probably rather pronounced fluvial environment preventing sedimentation of fine-grained particles. The latter explanation is supported by the existence of gravel and sand beneath zone Å1, which is correlated with at least the upper part of the Older Dryas Chronozone.

7.2.5. Lösensjön 50 m a.s.l. (Berglund 1966) (A)

According to Berglund (1976) this basin was isolated from the Baltic Ice Lake in the middle of the Salix - Hippophaë - Artemisia - Gramineae - Cyperaceae Assemblage Zone, corresponding to the Older Dryas Chronozone. The isolation level is estimated at 11,950 - 11,850 B.P. (Fig. 45).

7.2.6. Kroksjön 47 m a.s.l. (5)

This basin was isolated somewhere in the middle of zone K1, which is correlated to the Older Dryas Chronozone. The isolation is thought to have taken place some time between 11,950 and 11,850 B.P. (Fig. 45). The varved clay of layer 1 is correlated with zone K1 (Fig. 20), which is correlated with the Bölling Chronozone (Fig. 43a). This means that the predominant part of the varved clay should be older than 12,000 radiocarbon years and that Kroksjön was deglaciated at least 12,000 radiocarbon years + 300 varve years ago. As the highest shore line should be much younger than that, according to sites 2 and 3, the Baltic Ice Lake was either situated at the highest shore line during a rather long time period or transgressed up to the highest shore line. The increasing values of magnetite in the varved clay some time between the local varve years + 160 and + 170 (Fig. 20) could be explained by a transgression of the Baltic Ice Lake into the basin. However, if the basin became ice-free due to calving, caused by a rising water level, that is if a transgression really took place, this could also mean that the oldest varves in Kroksjön post-date the transgression into the basin. This discussion will be continued as part of a wider debate later on.

7.2.7. Dönhultagyl 44.5 m a.s.l. (6)

This basin is concluded to have been isolated at the boundary between zones D2 and D3, which corresponds with the boundary between the Older Dryas and the Alleröd Chronozones. The age of this boundary is fixed at 11,800 B.P. The isolation of Dönhultagyl I have thus estimated to have taken place between 11,850 - 11,700 B.P. (Fig. 45).

7.2.8. Sjalbredan 42 m a.s.l. (7)

The isolation of this basin has not been determined by micro-fossil analysis, but only by examination of the lithostratigraphy of the sediments. Four centimetres of the core just above the suggested isolation level has been radiocarbon dated to $10,990 \pm 135$ B.P. This date has led me to estimate the age of the isolation at 11,250 - 11,050 B.P. (Fig. 45).

7.2.9. Lilla sjön 39 m a.s.l. (8)

The isolation of this basin took place in the middle or latter part of zone L4. This zone is correlated with regional zone 4, which is dated to 11,400 - 11,000 B.P. The date of the isolation is concluded to have been some time between 11,200 and 11,050 B.P. (Fig. 45). It should be noted that, like in site 7, no varved clay has been found in the sediments correlated with the Bölling Chronozone.

7.2.10. Galtsjön 33 m a.s.l. (9)

Although zone G2 is correlated with zone 4, the lower boundary of zone G2 is not definitely synchronous with the lower boundary of zone 4 (Fig. 45). The upper boundary of zone G2 is radiocarbon dated as well as correlated with an age of 11,000 B.P. The isolation of Galtsjön seems to have taken place in the middle part of zone G2 and therefore dates to 11,300 - 11,100 B.P. (Fig. 45).

7.2.11. Halsjön I and II 30 m a.s.l. (10a and 10b)

This basin is interpreted as having been influenced by three isolations and two transgressions. At Fig. 46 these water level changes are related to the stratigraphical plot based on principal components analysis of the isolation indicators, excluding the magnetic susceptibility. It is clear that the development found in the two cores investigated from Halsjön (Figs. 28 and 29) is very much the same and it is possible to relate the water level changes interpreted from the two cores to the same stratigraphic positions. The first isolation took place in the middle part of zones HI2 and HII2, which correspond to zone 4 (11,400 - 11,000). This isolation is estimated to have occurred some time between 11,300 and

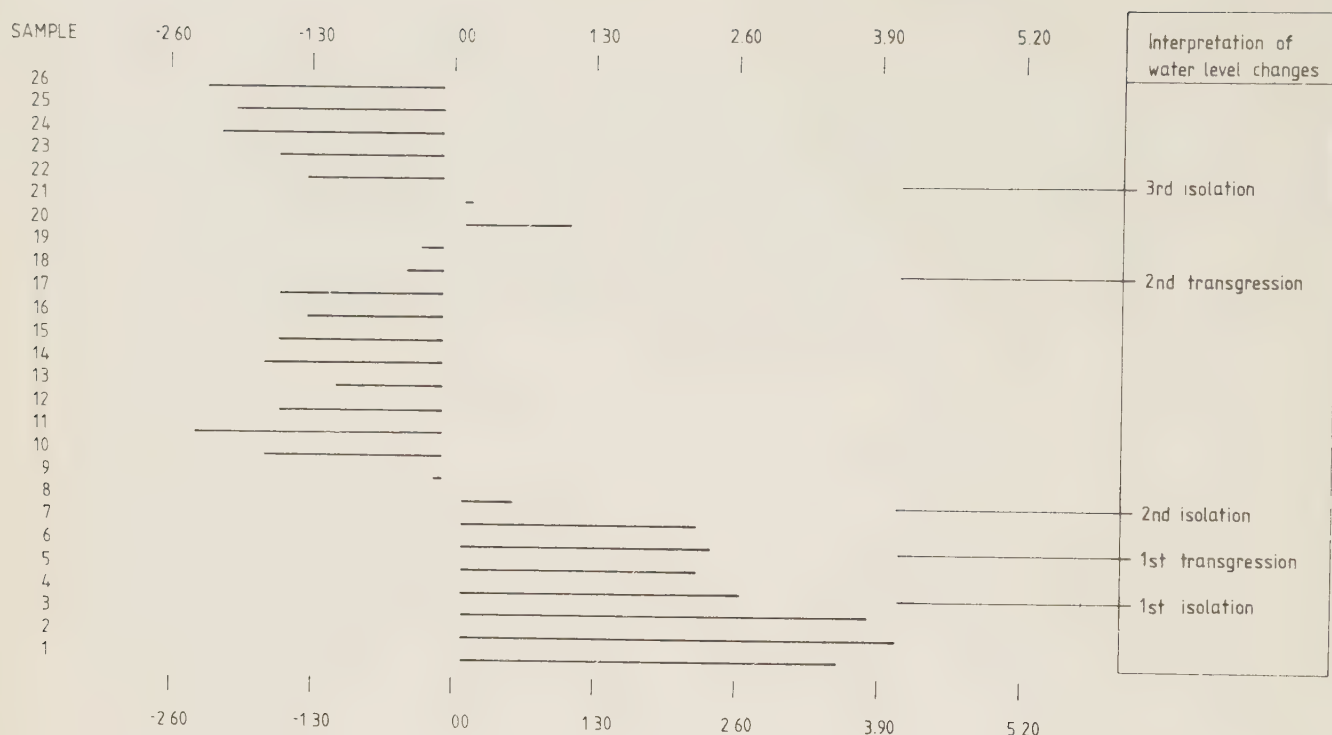


Fig. 46. Stratigraphic plot of sample scores on principal component 1 (60 % eigenvalue) based on correlation matrix of the isolation indicators, with the exception of magnetic susceptibility, from Halsjön II, related to the proposed water level changes.

11,100 B.P. (Fig. 45), and was later followed by a transgression. The transgression took place at or slightly above the boundaries between the zones HI2 and HI3 and HII2 and HII3. These boundaries coincide with the boundary between the Alleröd and the Younger Dryas Chronozones. The date of the transgression is calculated at some time between 11,000 and 10,900 B.P. The second isolation occurred in the lower part of zone HI3 and in the middle part of zone HII3. Zone HII3 corresponds with the lower third of zone 5 dated to 11,000 - 10,500 B.P. This isolation is thus calculated to have taken place some time between 10,950 and 10,850 B.P. (Fig. 45). The second transgression starts in the lower part of zones HI4 and HII6, corresponding to zone 6 (10,500 - 10,200 B.P.). At Halsjön II the sediment just beneath the level where the transgression is first registered has an age of $10,560 \pm 100$ B.P. This also dates the lower boundary of zones HI4, HII6 and the regional zone 6. Halsjön is concluded to have been transgressed some time between 10,500 B.P. and 10,400 B.P. The transgression climax at Halsjön II is dated to $10,740 \pm 105$ B.P., which is too old in view of the pollen

stratigraphy. As was pointed out in Chapter 6 this old date could support the interpretation that the Baltic Ice Lake extended into the basin. The uppermost part of zone HII6, which is correlated with zones HI4 and 6, is dated to $10,260 \pm 95$ B.P. The sediment level of this date coincides with the last isolation level, which means that this isolation took place some time between 10,300 and 10,200 B.P. (Fig. 45), corresponding to the end of zone 6. This also means that Halsjön was influenced by the Baltic Ice Lake for about 200 radiocarbon years.

7.2.12. F.d. Paddegölen 27.5 m a.s.l. (11)

The isolation level of this basin has a radiocarbon age of about 10,800 B.P. However, in Chapter 6 (Fig. 45) it was pointed out that this date is probably erroneous, which is also supported by the pollen stratigraphy. According to this the isolation occurred in the lower part of zone P5, which corresponds with the upper part of zone 6. These correlations make it possible to date the isolation to some time between 10,400 - 10,200 B.P. (Fig. 45).

7.2.13. Norrsjön 25 m a.s.l. (12)

The isolation of this basin took place at the boundary between zones N2 and N3. Zone N3 corresponds to the uppermost part of zone 6. On the basis of this correlation the isolation of Norrsjön should be dated to some time between 10,300 and 10,200 B.P. (Fig. 45).

7.2.14. F.d. Togölen 20 m a.s.l. (13)

This basin was isolated in the middle part of zone T6, which corresponds with the upper part of zone 6 (10,500 - 10,200). The date of the isolation is estimated at 10,300 - 10,200 B.P. (Fig. 45).

7.2.15. Getsjön 19 m a.s.l. (14)

Getsjön was isolated in zone Get1, which partly resembles zones T6 and N3. As these are correlated with the upper part of zone 6, and zone Get1 is also correlated with zone 6, it seems probable that the isolation took place in the upper part of zone 6, dated

to some time between 10,300 and 10,200 B.P. (Fig. 45).

7.2.16. Karstorpsjön 18.5 m a.s.l. (15)

Although the pollen stratigraphy from this site is divided into local pollen assemblage zones, this zonation is not regarded as reliable due to disturbances in the sediments. However, the basin was isolated with certainty some time during the latter part of the Younger Dryas Chronozone.

7.2.17. Bredsjön 15 m a.s.l. (16)

As the radiocarbon date of the isolation level of this basin is regarded as being much too old (Fig. 37), this level has to be dated by the pollen stratigraphy. Bredsjön was either isolated in the upper part of zone B1 or in the very lowest part of zone B2. Zone B2 corresponds with zone 7 (10,200 - 10,000 B.P.), while zone B1 corresponds with zone 6. As this boundary is dated to 10,200 B.P. the isolation is estimated to have occurred some time between 10,300 and 10,150 B.P. (Fig. 45).

7.2.18. Hallarums mosse 4 m a.s.l. (Berglund 1966) (B)

According to Berglund (1966) this basin was isolated from the Baltic Ice Lake just before the Younger Dryas - Preboreal Transition Period. It is possible to correlate this period with zone 7 with respect to the pollen assemblage. This means that the basin was isolated some time between 10,300 and 10,200 B.P. (Fig. 45).

7.3. Late Weichselian shore line displacement in Blekinge with comparisons to investigations in other parts of the Baltic

7.3.1. Blekinge

The synthesis of the sediment stratigraphy and the dated isolation levels of the basins investigated produces a shore line displacement curve for the investigation area. It should, however, be noted that such a curve is based solely on interpretations of the stratigraphy of a certain number of sites. This means that such a

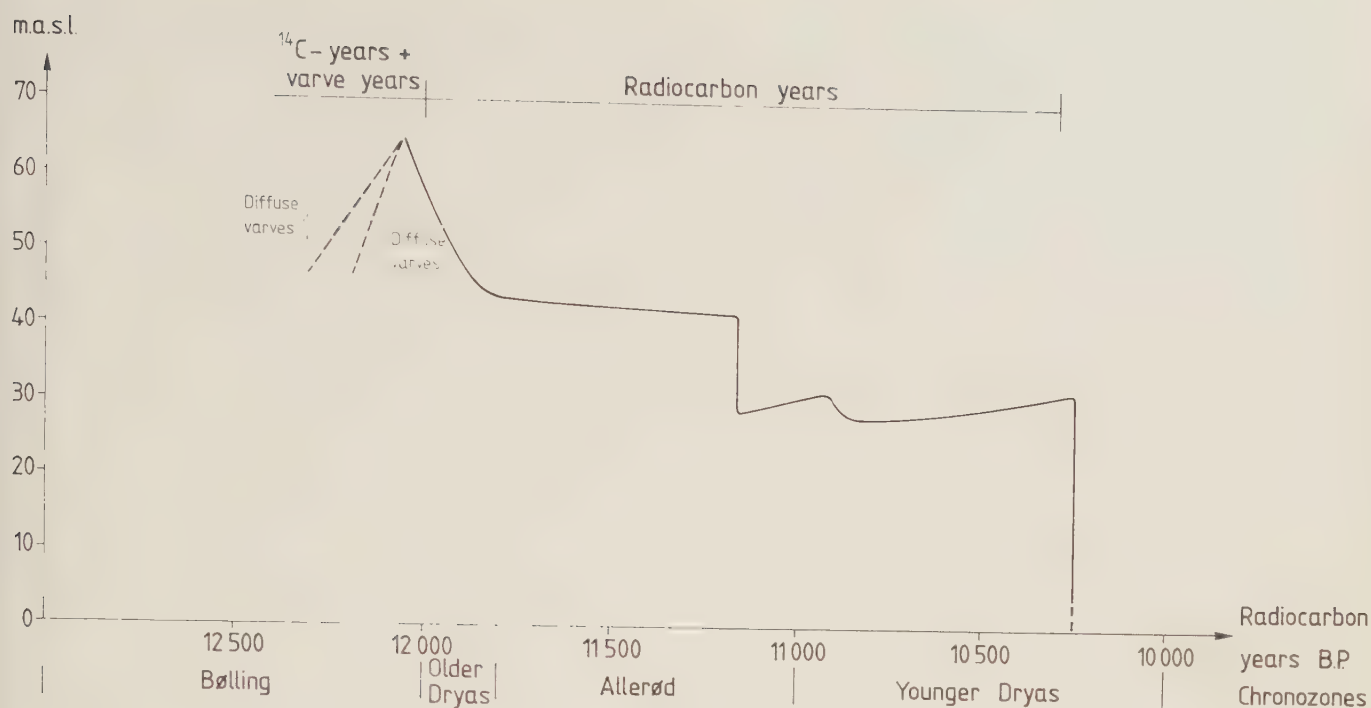


Fig. 47. A Late Weichselian shore line displacement curve for Blekinge, SE Sweden, mainly based on dates of the isolation level of 15 basins situated below the highest shore line.

curve would possibly change, at least slightly, if more sites were investigated. It also means that as the curve is based on interpretations of stratigraphic material, the curve changes if these interpretations are adjusted or revalued. In the light of these reservations a shore line displacement curve for Blekinge during the Late Weichselian is shown in Fig. 47.

The main reasons found in the basins for the theory that the deglaciation was not preceded by a regression but probably by a transgression are the following.

- 1/ The highest shore line is determined by Ringberg (1971), at 25 different localities, to be 63 - 67 m a.s.l.
- 2/ The stratigraphy at Vitavattsgyl (site 1) shows that the Baltic Ice Lake did not influence this basin (71 m a.s.l.), although the oldest sediments were formed during the Bölling Chronozone.
- 3/ The stratigraphy at Logylet (site 3) shows that the sediments deposited before the isolation covers a time-span of more than 100 varve years. Presuming that the altitude of the highest shore line is correct (Vitavattsgyl and Ringberg, 1971) and that

the deglaciation was followed by an immediate regression, this would mean that the regression gradient from about 65 m a.s.l. down to Logylet (61 m a.s.l.) must have been less, probably much less, than 5 m/100 years. An explanation for this low gradient could, however, be the fact that the varved clay and clay at Logylet was formed during a transgression as well as during a regression and thus fit into the recorded gradient of 10 m/100 years. The change of the magnetite content in the varved clay could have been caused by a transgression into the basin.

- 4/ The stratigraphy at Sannen (site 2) shows that this basin (64 m a.s.l.) was deglaciated some time before it was isolated from the Baltic Ice Lake, as the sediments correlated with the Bölling Chronozone are rather thick. It is possible that the lowermost, probably glaciogenic sediments were formed even before the assumed transgression reached into the basin, which is also the case at Logylet.
- 5/ The stratigraphy at Kroksjön (site 5) shows that this basin was deglaciated more than 300 years before the isolation. If the deglaciation was synchronous with the development of the highest shore line, it would mean that the regression was less than 6 m/100 years compared with the recorded gradient of 10 m/100 years. However, if a transgression is included within this time-span a more probable gradient is obtained.

As has been pointed out above, it is most likely that the highest shore line is younger than the deglaciation. It was also shown that the stratigraphy in Kroksjön could indicate a transgression during or before the deposition of varved clay. However, as the stratigraphy can be interpreted in two ways, and thus also give two different dates for this possible transgression, these two dates are the starting points for the two broken lines up to the highest shore line, which according to Ringberg (1971) is situated at about 65 m a.s.l. It is also possible that the transgression gradient is even less than is shown in Fig. 47 if the first varved clay in Kroksjön was deposited some time after the transgression had reached the altitude of the threshold of Kroksjön. This means that it is for the moment impossible to determine the transgression gradient. The assumption, based mainly on pollen stratigraphy, that the varved clay in Blekinge was deposited during the Bölling Chronozone is supported by the fact that no varved clay is found either

at Dönhultagyl (site 6) or at Lilla sjön (site 8) and that the deposition of varved clay in Logylet (site 3) and Sannen (site 2) stopped before these two basins were isolated at the boundary between the Bölling and the Older Dryas Chronozone. The regression of the Baltic Ice Lake seems to have started at the very end of the Bölling Chronozone, and the gradient for the regression during the first 150 years is, according to the curve, more than 10 m/100 years. However, the dates from this time period are based on pollen-stratigraphical dating related to a time scale based on radiocarbon years. Furthermore, the variations in ^{14}C are unknown in this time period. The gradient for the following 100 years is 4 m/100 years. The major part of the Alleröd Chronozone is characterized by an extremely low regression gradient (0.4 m/100 years). It is clear from Fig. 47 that a very sudden regression takes place in the latter part of the Alleröd Chronozone, with a water level change of about 15 m during a very short time-span. This rapid regression is followed by a probably rather slow transgression. The amount of this transgression is calculated to 2 to 4 metres. Whether the following regression was rapid or not depends on its cause, but it is drawn as a rather sudden event. The next water level change in the area is a slow transgression up above 30 m a.s.l. This rather steady development is interrupted by a sudden lowering of the Baltic Ice Lake level, from more than 30 m a.s.l. down to at least 4 m a.s.l., which is dated to the very end of the Regional Assemblage Zone 6. Whether this event consists of a series of lowerings or of one major sudden lowering is not possible to say.

In Chapter 2 Berglund's (1966) shore line displacement curve from Blekinge was shown (Fig. 7). It is obvious that this curve partially resembles the curve shown in Fig. 47. However, Mörner (1969) altered Berglund's curve (Fig. 48). The reason for this was that Mörner meant that the curve would be much more reliable if the highest shore line in Blekinge has the same age as Mörner's Fjärås line. This alteration means that Mörner, unlike Berglund, got a smooth curve throughout the Late Weichselian. The reason why Mörner wanted a smooth curve was that he thought that the sea level corresponded to the level of the Baltic Ice Lake during the development of the highest shore line ('ML' according to Mörner), and that the Late Weichselian shore line displacement curve in Blekinge was almost only controlled by the isostasy in Blekinge until the

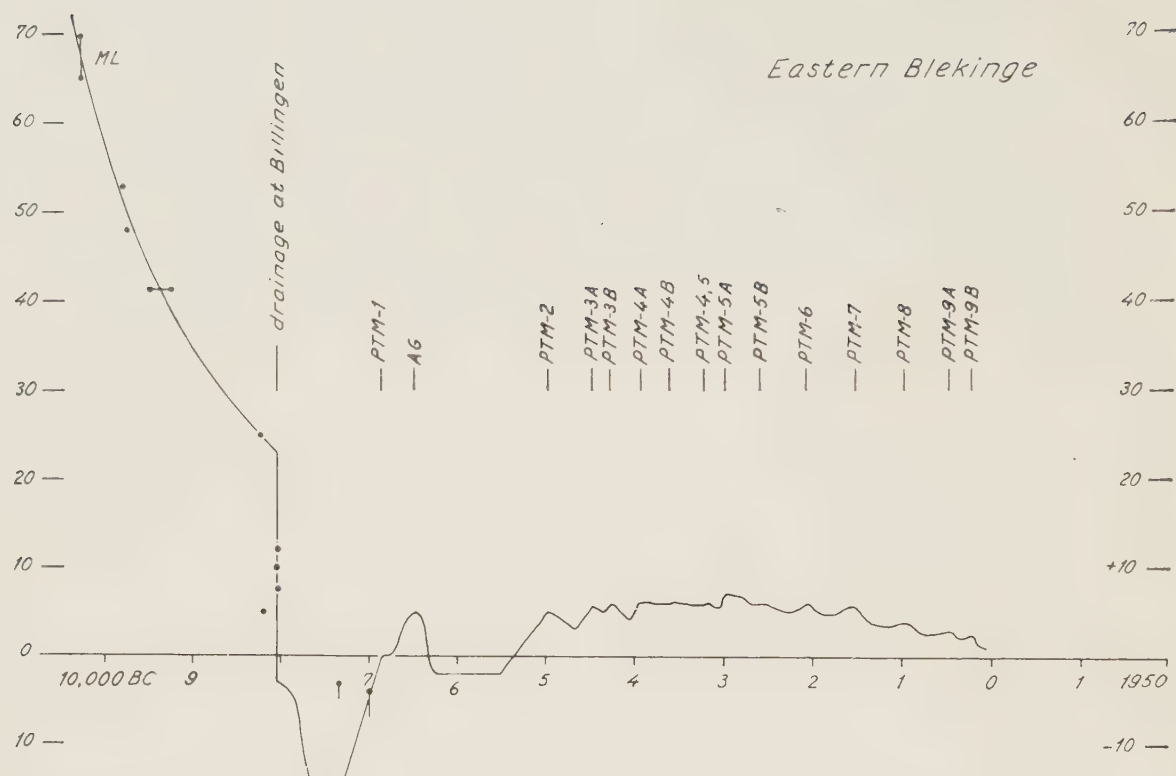


Fig. 48. Mörner's (1969) shore line displacement curve for eastern Blekinge, based on alterations of Berglund's (1964 and 1966) curves.

Baltic Ice Lake was lowered 26 m by the drainage at Billingen. As is shown in Fig. 47 and will be discussed in Chapter 12, the development of the Baltic Ice Lake seems to have been quite different from what Mörner thought, as the shore line development curve in Fig. 47 is believed to reflect a complex of events, such as e.g. the isostasy in different parts of the Baltic basin, the eustasy of the Baltic Ice Lake, erosion of thresholds and deglaciation of threshold areas.

7.3.2. Lithuania (SSSR)

Gudelis (1961) published a shore line displacement curve, mainly based on stratigraphical changes, for the Lithuanian Baltic coast, which is shown in Fig. 49. In Gudelis (1979) he described this curve further. The chronology of the Late Weichselian in Fig. 49 is mainly based on correlations with 'the Swedish Time Scale' of the varve chronology (Nilsson 1960). The earliest development of the Baltic Ice Lake in Lithuania was by Gudelis (1979) called 'the stage of the Baltic ice-dammed lakes (13,000 - 12,200 years B.P.)', which

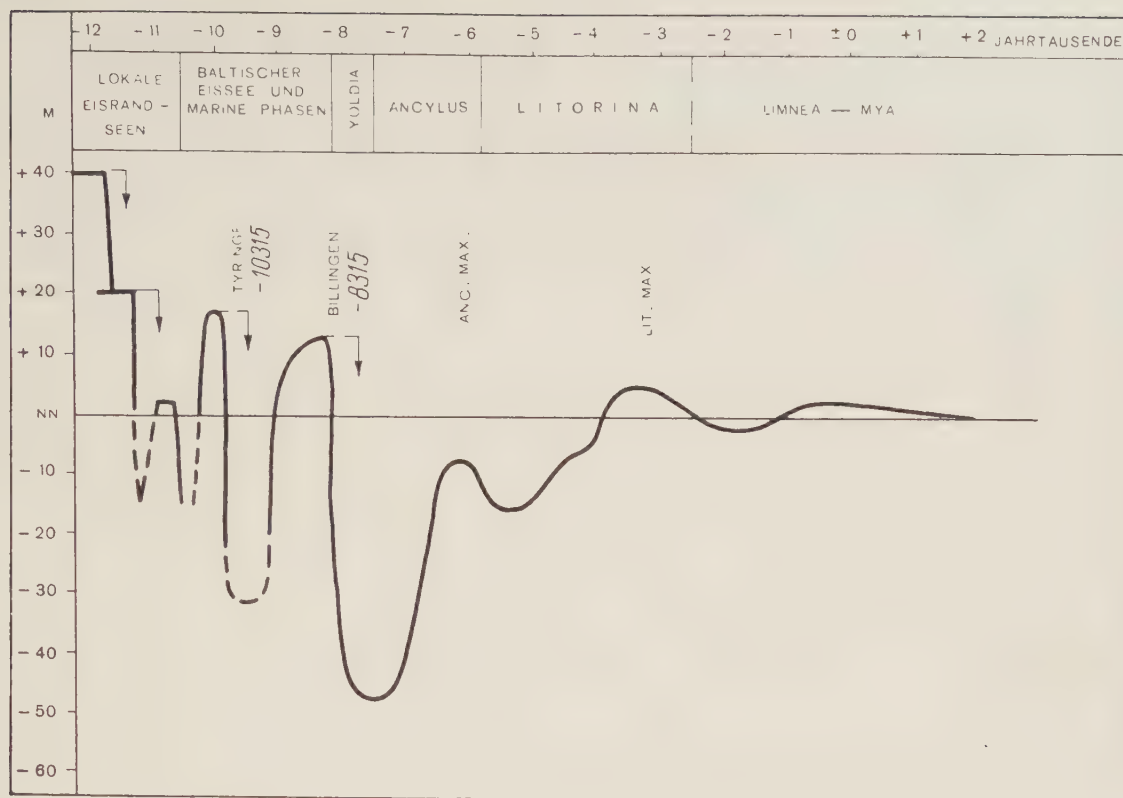


Fig. 49. A shore line displacement curve from the Lithuanian Baltic coast according to Gudelis (1961).

he divided into two phases, namely 'the phase of local, ice-dammed lakes and the phase of the South Baltic Ice Lake'. The next stage he called 'the Baltic Ice Lake and its marine phases (BIL)' lasting between 12,000 and 10,200 years B.P. This means that Gudelis thought that the Baltic Ice Lake partially was influenced by the sea, which there seems to be no evidence for in Blekinge. It is, however, noteworthy that Gudelis has evidence for a marked transgression during the Younger Dryas culminating at the end of Younger Dryas. The amount of this transgression seems to have been at least 20 m, which can be compared with the amount calculated from Blekinge (Fig. 47) and Finland (Fig. 50).

7.3.3. Finland

Donner (1969) presented a schematic land/sea level curve for southern Finland (Fig. 50). This curve, which was based on morphological features, was related to the varve chronology as well as to the Salpausselkä end moraines and later also to the radiocarbon chronology (Donner 1978). Donner thought that the earliest recorded

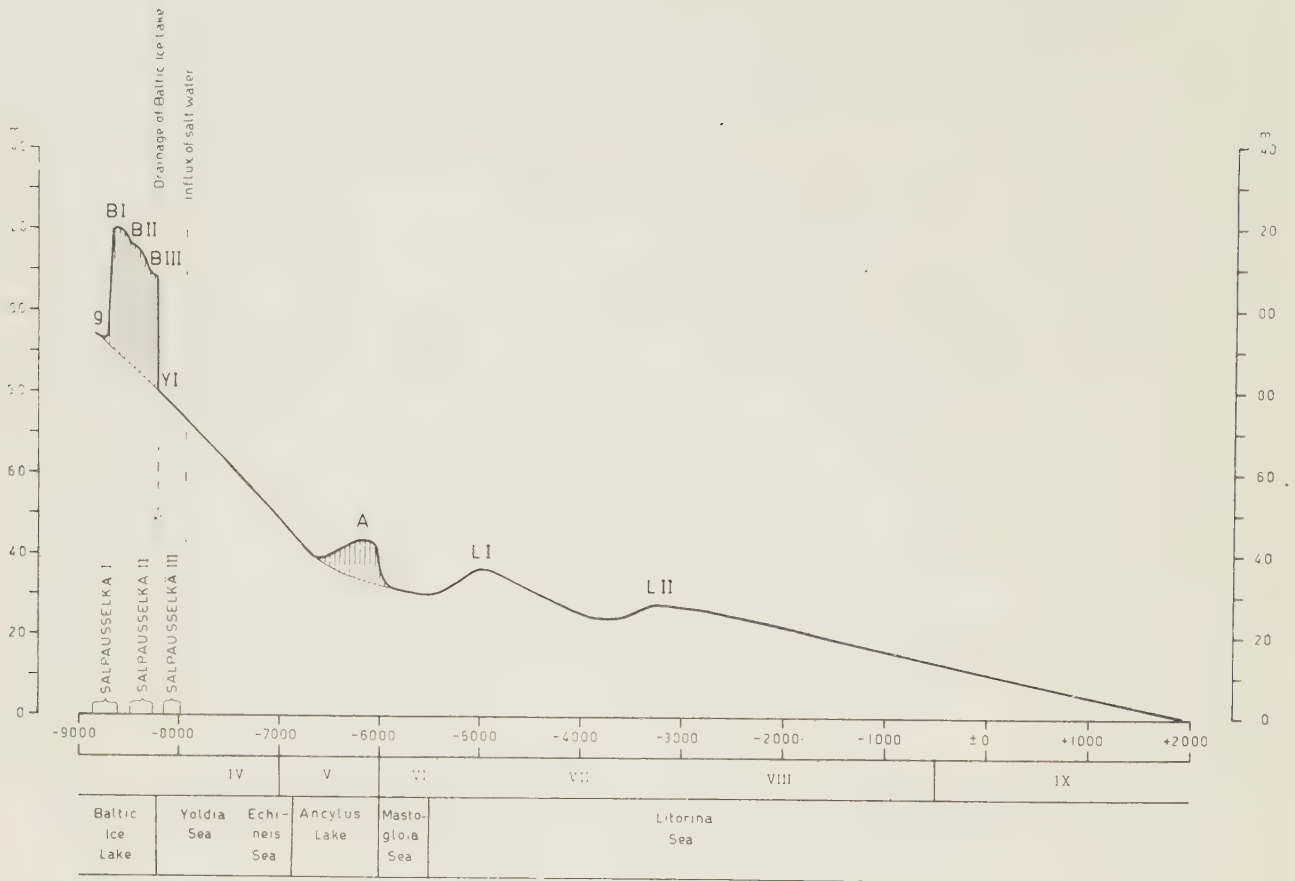


Fig. 50. A curve for the land/sea level changes at Helsinki, southern Finland, according to Donner (1969).

development of the Baltic Ice Lake in Finland was characterized by the so-called g-level, possibly reflecting the sea level. This was followed by a transgression up to the B I level during the early Younger Dryas, due to damming of the Baltic Ice Lake. The amount of the transgression was, according to Donner (1969), 25 m. This was later followed by a regression of about 10 m (the B II and B III levels) before the final drainage down to the Y I level, which caused a lowering of the water level of about 28 m, which was correlated to 'the last drainage of the Baltic Ice Lake at Billingen' (Donner 1969, p. 147). Apart from the amount of the transgression during the early Younger Dryas, the development described by Donner in many ways fits to the development shown in Fig. 47. These resemblances together with the question whether the Baltic Ice Lake was connected with the ocean before the transgression, which Donner (1969) believes could have been the case for about 200 years, will be discussed in Chapter 12.

It is obvious from the comparisons above that these four quite different shore line displacement curves (Figs. 47, 48, 49 and 50) are calculated in four different ways from three different areas. This is the main reason why one should not try to compare these curves in detail, but more look at the general tendencies and from these try to explain any differences, which partially will be done in Chapter 12.



Fig. 51. Map showing the position of the described river valleys (1-4) and their described sites as well as the esker systems investigated (A-I).

8. DESCRIPTION AND STRATIGRAPHY OF THE INVESTIGATED RIVER VALLEYS

This chapter will deal with investigations of gravel pits and different kinds of borings in some of the river valleys of Blekinge. Not all the sites investigated will be described, but only the most interesting and typical sites in each valley. The geography, morphology and stratigraphy as well as the interpretation of the local development of each site will be described. Local lithostratigraphic units will be distinguished for each river valley. These units will be related to the regional lithostratigraphic units established by Lagerlund and Björck (1979).

The river valleys will be described from west to east (1-4) and the position of each valley and site is shown in Fig. 51. Two of the valleys investigated, the Hällarydså and the Vierydså river valleys, are not described in this work. This is due to the incompletely described stratigraphy of these small valleys, which is the result of the lack of a sufficient number of suitable sites. However, the Hällarydså river valley will be mentioned in connection with the description of the deglaciation, as the stratigraphy in this valley partly resembles the stratigraphy in the Mörrumså river valley (Lagerlund and Björck, 1979).

8.1. The Mieå river valley (1)

This river (Fig. 51) drains Lake Mien which is located 25 km north of Karlshamn. The size of the whole drainage area is 295 km². The northern part of the river valley consists of a deep bed-rock dependent fissure valley. In the southern part the river flows through many lakes and the valley widens. From Lake Långasjön and northwards the valley is often occupied by gravel deposits, either shaped as ridges in the middle of the valley or as terraces on the valley slopes. From Lake Långasjön and southwards, silty and clayey deposits dominate the valley. The outlet of the Mieå river lies in the southwestern part of Karlshamn. A profile of the southern part of the Mieå river valley is shown in Fig. 52.

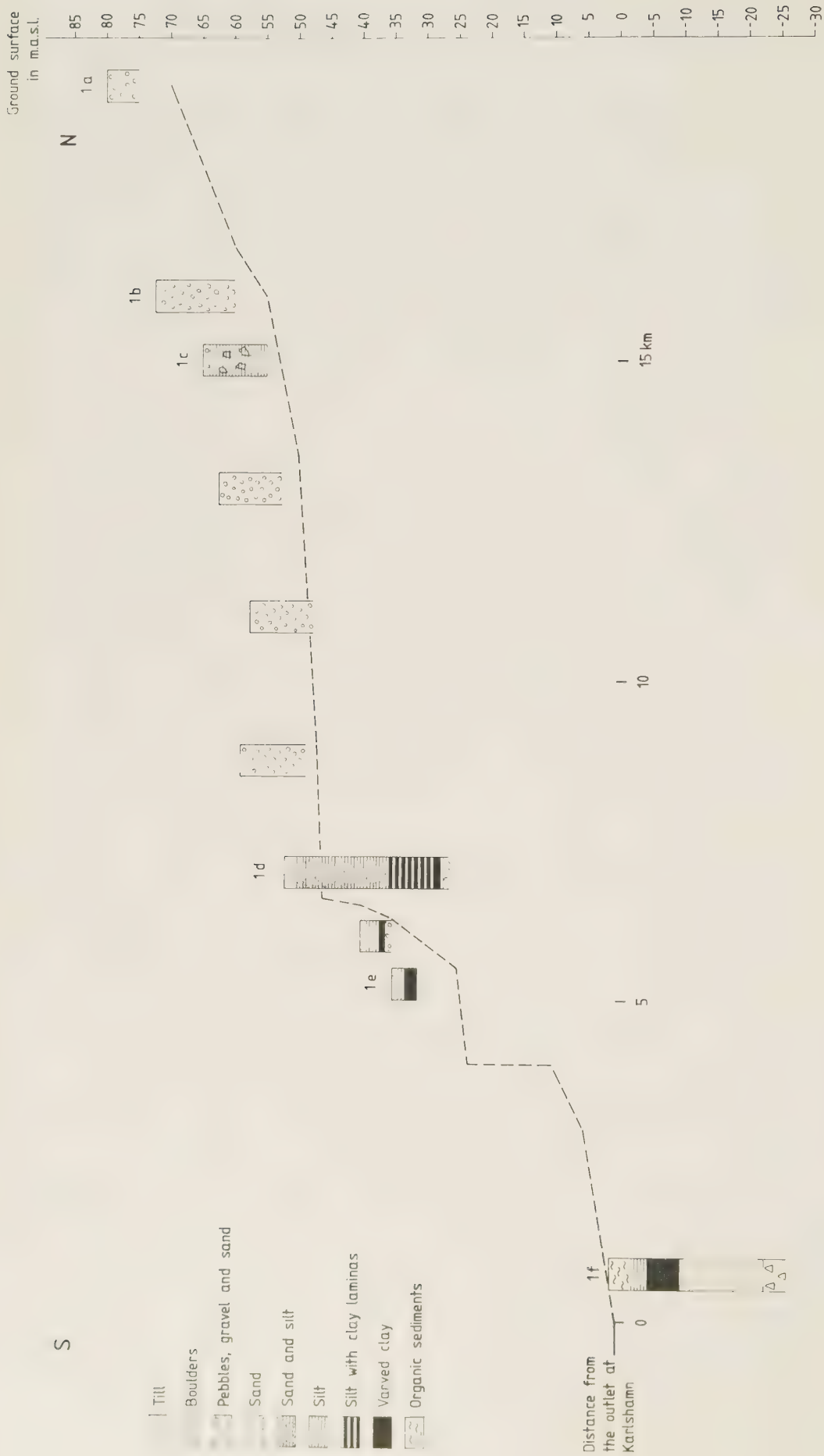


Fig. 52. A profile of the southern part of the Mieã river valley. The lithostratigraphy derives from gravel pits and bore-holes and site 1a to 1f are further described in the text. The dotted line represents the altitude of the Mieã river.

8.1.1. Dannemark (1a)

This site is located 1 km south of Ire (Fig. 51). The narrow and deep valley dominates the surroundings. On the western side of the valley lie two terraces, situated 80 and 75 m a.s.l. respectively. In the lower terrace, which is very flat, there is a gravel pit. The slope down to the Mieå river is very steep.

The sediments in the gravel pit have been divided into four strata (1a 1 - 1a 4).

- 1a 1 This stratum, the uppermost recorded from Dannemark, consists of gravel, pebbles and boulders. The material observed is mostly unstratified, but some parts of the gravel are stratified. Pebbles and boulders are well rounded. The maximum thickness of this stratum is 2.0 m. The lower boundary is very distinct, but also very disturbed. Dip and orientation analysis of the stratified gravel shows that the material was transported from NNE.
- 1a 2 This stratum consists of stratified sand. The thickness varies between 0.0 and 0.5 m. The lower boundary is very sharp. Dip and orientation analysis shows that the material was transported from ENE.
- 1a 3 This stratum consists of stratified silty sand. Cross-lamination formed by ripple migration is found in the upper part of the stratum. The material is laminated with silty and sandy laminae. The thickness of the stratum varies between 0.0 and 0.5 m. The lower boundary is very distinct. Dip and orientation analysis shows that the material was transported from NNE.
- 1a 4 Consists of stratified coarse sand. The thickness of this stratum is at least 0.2 m.

This formation is interpreted as a kame terrace, deposited between the ice and the valley slope. This is supported by the steep slope from the terrace down to the bottom of the river valley, which is interpreted as an ice-contact surface. The variety of grain-size

between the strata shows that the melt-water flow varied considerably.

8.1.2. Norrefors (1b)

This site is located 200 m NW of Norrefors (Fig. 51). The river valley widens and the valley slopes are more gentle than further northwards. The investigated gravel pit lies west of the river in a ridge with very steep slopes, with the upper surface situated between 70 and 75 m a.s.l. This surface is characterized by rather deep circular depressions.

The sediments in the part of the section visible were divided into two strata (2b 1 - 2b 2).

1b 1 This stratum is characterized by coarse material, consisting of gravel, pebbles and boulders. The material is rather well rounded, but poorly sorted. The thickness varies between 1 and 3 m, and the lower boundary is very distinct.

1b 2 This is the lowermost recorded stratum from Norrefors, and it consists of stratified sand and silt. The sandy parts of this stratum are cross-bedded. Some parts of the stratum are laminated with silty and sandy laminae. The material is well sorted. The visible part of this stratum has a maximum thickness of 4 m.

This ridge is interpreted as being an esker, formed in a channel/tunnel surrounded by ice. The very steep slopes of the esker are thus formed by ice-contact. The large change in velocity of the transporting melt-water between the two strata probably reflects a lowering of the ground-water table in the ice. The depressions on the top of the esker are most probably kettle holes.

8.1.3. Jeppshoka (1c)

This site is located just north of Jeppshoka (Fig. 51). The valley is about 500 m wide, but becomes narrower southwards. The site consists of a large gravel pit, 500 m long and 200 m wide, which in the northern part has open sections. Because of the heavy exploita-

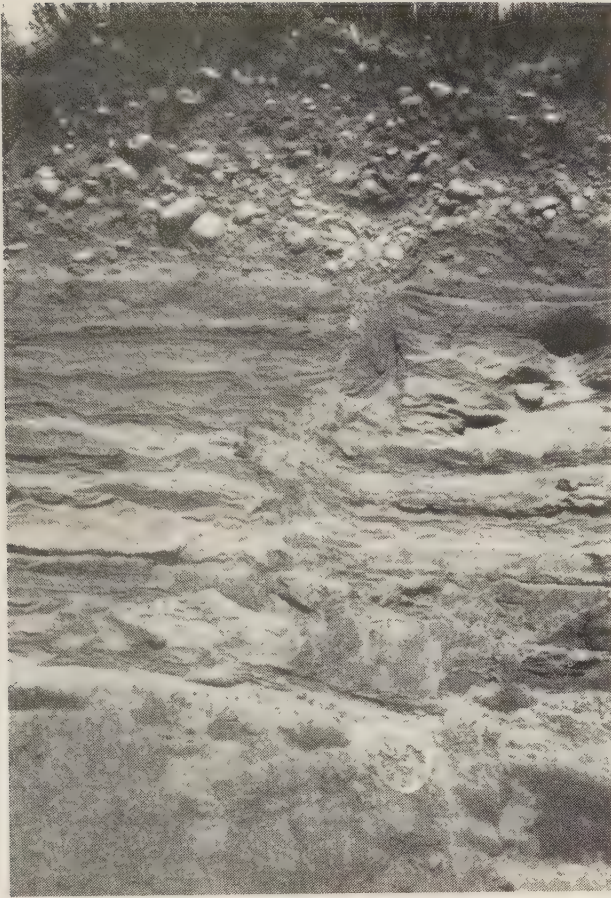


Fig. 53. An ice-wedge in Jeppshoka, extending down from stratum 1c 1 to stratum 1c 2.

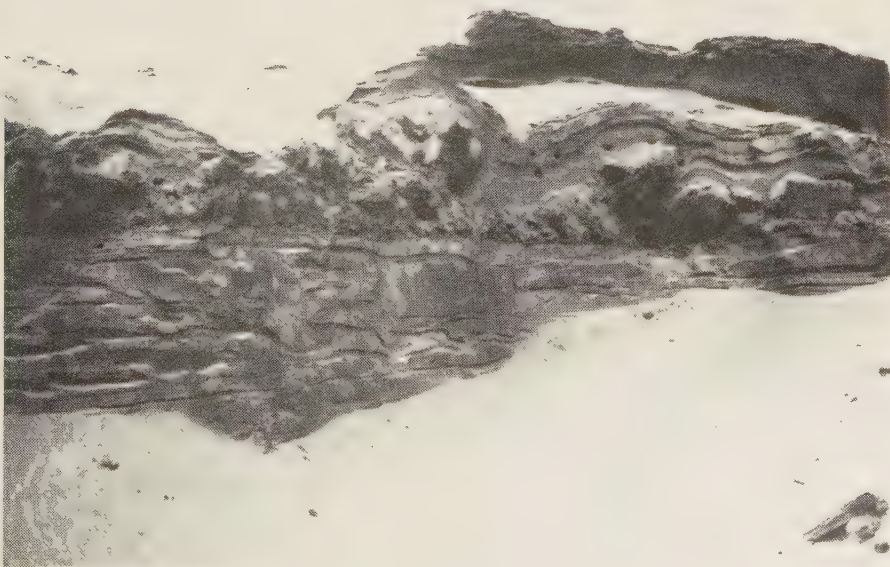


Fig. 54. A boulder horizon in stratum 1c 2.

tion of the area, it has been difficult to obtain an idea of the original morphology. The older aerial photos show that the area was rather flat with steep slopes down to the river in the east, while the slope southwards was much more gentle. Westwards the area is restricted by till covered bed-rock, situated about 70 m a.s.l. The esker described at site 2b continues up to the northern part of Jeppshoka, where the marked esker shape disappears. The site was originally situated between 60 and 65 m a.s.l. The river Mieå is situated slightly above 50 m a.s.l.

The sediments in the gravel pit have been divided into three strata (1c 1 - 1c 3).

- 1c 1 This is the uppermost stratum at Jeppshoka. It consists of gravel and pebbles with some indistinct cut and fill structures. Two ice-wedges have been found in this stratum (Fig. 53) in the northeastern part of the gravel pit. The material is well rounded and poorly sorted and the thickness of the stratum varies between 0.5 and 3 m. The lower boundary is very distinct.
- 1c 2 This stratum consists of sandy silt with boulders. It is more or less horizontally stratified with cross-lamination formed by ripple migration. The ice-wedges described in stratum 1c 1 extend down into this stratum (Fig. 53). The abundance of sharp-edged boulders is characteristic (Fig. 54). They are usually found in continuous horizons. Boulders up to about 5 m³ have been found. The stratification just beneath the boulders is disturbed and the overlying sediments follow the topography of the boulders very closely. The thickness of this stratum is about 5 m. The lower boundary is gradual. Dip and orientation analyses show that there is no preferred transport direction for this stratum.
- 1c 3 This stratum is the lowermost recorded from Jeppshoka, and it consists of silt, sand and gravel. The material is cross-laminated as well as cross-bedded and the different laminae and beds are well sorted. Some boulders have also been found in this stratum. The thickness of

this stratum observed varies between 3 and 5 m.

This formation is interpreted as a kame delta, deposited between the till covered bed-rock in the west and ice east- and southwards. Probably ice also occupied the area north of the gravel pit where the esker described at site 1b is located. Strata 1c 2 and 1c 3 are presumed to have been deposited in an ice and bed-rock dammed lake. This is supported by the facts that ice-contact surfaces exist, that the sedimentation for the most part has been calm and that no preferred transport direction exists for the sediments belonging to stratum 1 c 2. The boulders have probably been transported by lake ice from the surrounding ice and/or till into the lake and deposited at more or less the same time as when the ice in spring-time became too weak. Stratum 1c 1 is interpreted as being a top-set bed, deposited at or above a water level. This water level could very well have been the level of the Baltic Ice Lake, whose highest coast line in Central Blekinge is about 65 m a.s.l. (Ringberg, 1971). This is supported by the lack of any clear ice-contact in the south. A former ice-contact surface could be buried beneath stratum 1c 1 and be today only represented as a gentle slope. The sudden change between strata 1c 1 and 1c 2 can thus be explained by a tapping of the former ice dammed lake down to a regional water level represented by the Baltic Ice Lake.

8.1.4. Tararp (1d)

This site (Fig. 51) consists of two gravel pits, many boreholes and a lot of dug sections. The stratigraphy described in connection with this site is a summary of the stratigraphy described by Sandgren and Åmark (1975). The area is located 3 to 4 km NE of Asarum, east and southeast of Lake Långasjön. It is characterized by rather even topography, situated between 45 and 55 m a.s.l. The area is delimited by till covered bed-rock, reaching altitudes of about 75 m a.s.l. The river valley between sites 1c and 1d is characterized by continuous esker systems.

The sediments at Tararp have been divided into five strata 1d 1 - 1d 5).

1d 1 This stratum, the uppermost recorded from Tararp, consists mainly of unstratified fine sand. It is most common in

the vicinity of till and in the lower parts of the area. The thickness of this stratum varies between 0 and 2 m.

- 1d 2 This stratum, which consists of gravel and sand, has been very carefully investigated with respect to structures. The observed cut and fill stratification with foresets and troughs has been investigated in detail. The thickness of the sets is more than 5 cm, which means that the structures were formed by dune migration. Analyses show that the material was transported from the west. This stratum is only present at altitudes of more than 50 m a.s.l. The thickness of this stratum does not exceed 1.3 m and the lower boundary is very distinct.
- 1d 3 This stratum consists of sand and silt. It is usually cross-laminated with a gentle dip, except for some sandy parts where the dip is more steep. This steeper dip also characterizes the finer material in the southeastern part of the area where there is a marked slope. The thickness of this stratum is usually between 2 and 4 m. The lower boundary is gradual. Dip and orientation analyses show that the material was transported from the northwest.
- 1d 4 This stratum is dominated by silt interbedded with fine sand and clay. Ripple structures are present in the silt as well as in the fine sand. The dip of the different sets is very gentle. The clay laminae are reddish brown and usually not thicker than 5 mm. With increasing depth the grain-size decreases, which also means that the number and size of the clay laminae increase with the depth. At one boring 164 clay laminae were counted without reaching the underlying stratum. Some of the bottommost laminae were between 10 and 25 mm thick. The greatest depth found for stratum 1d 4 is 23 m. The lower boundary is distinct. Dip and orientation analyses show that the material was transported from the northwest.
- 1d 5 This is the lowermost recorded stratum from the Tararp area. It consists of sand, gravel and pebbles, and is found at the surface in the western part of the area,

where these sediments have been deposited as terraces or well marked ridges. They are situated between 50 and 65 m a.s.l. and are most common near the shore of the southern part of Lake Långasjön. Almost 1 km south of Lake Långasjön this stratum is found underlying stratum 1d 4. This has been documented from a bore-hole. Cut and fill stratification has been observed in the sandy material, but usually most of the structures found are very disturbed. The thickness of this stratum is estimated to about 10 m in a ridge west of Lake Långasjön. In the borings a maximum thickness of 1.2 m has been found. Dip and orientation analyses show no preferred transport direction, because of the many disturbances in the material.

Stratum 1d 5 is interpreted as being deposited at the deglaciation of the area. The terraces and ridges are interpreted as kame terraces and eskers. The disturbed structures in these sediments are probably caused by collapses, when the surrounding ice finally melted and caused secondary dips and orientations. Stratum 1d 4 is interpreted as a bottomset bed in a delta, formed by deposition in suspension as well as by bed load transport. This stratum is thought to be synchronous with parts of the local varve chronology established by Ringberg (1979). The material was transported from the northwest, which means that the water depositing the delta probably came from the valley of Lake Långasjön. The reason why the delta was not formed at the southern shore of the lake can be explained by the presence of dead-ice blocks in this part of the lake. This is supported by the fact that glacio-fluvial material (stratum 1d 5) completely dominates this area. Stratum 1d 3 seems to be a continuation of stratum 1d 4 and can be partly regarded as a foreset bed formed by bed load transport. This is especially the case for the southeastern part of the delta, where the distal slope is situated, and for the coarser parts of this stratum. The difference between these two strata can be related to changes in the flow, caused by changing water depth and/or changes in the amount of transporting water. The lack of clay laminae in stratum 1d 3 is either caused by such changes or by the absence of a glaciogenic influence. Stratum 1d 2 is interpreted as a topset bed in a delta. The cut and fill stratification with throughs and parallel sets

shows that the material was transported in a braided river system in a more or less pronounced subaerial environment. The distinct boundary between strata 1d 2 and 1d 3 could have been caused either by erosion or by a sudden change of the sedimentation environment without any extensive erosion. Stratum 1d 1 is interpreted as redeposition of material from the surrounding till and/or delta sediments principally by wave action. These interpretations coincide well with the interpretations made by Sandgren and Åmark (1975).

8.1.5. Hanamo (1e)

This site consists of a narrow valley located southeast of the village of Tararp and north of Hanamo (Fig. 51). Five borings were carried out and described by Sandgren and Åmark (1975). The valley is situated between 25 and 35 m a.s.l., and is surrounded by till covered bed-rock. In the north the valley is connected with the Tararp area by a narrow passage with the threshold situated 45 m a.s.l.

The sediments in Hanamo have been divided into three strata (1e 1 - 1e 3).

- 1e 1 This stratum, the uppermost recorded from Hanamo, consists of sand. The thickness varies between 1 and 2 m and the maximum thickness is found in the higher parts of the valley slope near to the till.
- 1e 2 This stratum consists of sandy silt and its maximum thickness (about 1 m) is found in the lower parts of the valley.
- 1e 3 This is the lowermost recorded stratum in Hanamo and it consists of clay and silt. The amount of clay increases rapidly with increasing depth. At one boring 2 m of laminated clay was found without reaching the bottom of this stratum.

Stratum 1e 3 is interpreted as being a distal deposit of stratum 1d 4 in Tararp, which explains why stratum 1d 4 is coarser. This means that stratum 1e 3 is synchronous with parts of the local

varve chronology. Stratum 1e 2 is more difficult to interpret, as it has been impossible to study eventual structures. But it is thought as a distal sediment of stratum 1d 3 and maybe also stratum 1d 2 at Tararp and perhaps also mixed with sand from wave washed till. Stratum 1e 1 is interpreted as being redeposited material, formed mainly by wave washing of till. This sediment is related to the regression of the Baltic Ice Lake.

8.1.6. Karlshamn (1f)

This site is located in the central part of Karlshamn, 300 m NNE of Hinseberget, just east of the river Miedå (Fig. 51). The surface of the eastern part of the site is situated about 8 m a.s.l., while the westernmost part is situated around sea level. This is because the bed-rock dips rather steeply from east to west. The site consists of a 50 x 100 m hole, about 5 m deep in the eastern part. Investigations in this part of the pit have been complemented by the results from borings carried out by the company AB Jacobsson and Widmark in Karlskrona, which have been put at my disposal.

The sediments in Karlshamn have been divided into five strata (1f 1 - 1f 5).

- 1f 1 This stratum, the uppermost recorded from Karlshamn, consists of gyttja. Its thickest part is situated just east of the river, where 7 m of this stratum is found. It is completely missing in the eastern part of the site.
- 1f 2 This stratum consists of slightly silty sand. It is cross-laminated. The thickness varies between 2 and 8 m and this stratum is found only in the eastern part of the site. Dip and orientation analyses show that the material was transported from the northwest.
- 1f 3 This stratum is a laminated sediment, with silt and clay laminae. The clay laminae are usually thicker than the silt laminae, with the exception of the lowermost parts of this stratum, where silt is the dominant grain-size. The thickness varies between 0 and 10 m, and the greatest thickness is usually found in the western part of the site.

- 1f 4 This often very thick stratum consists mainly of sand with a smaller content of gravel, pebbles and boulders. 20 m of this stratum is found just east of the river.
- 1f 5 This is the lowermost recorded stratum from Karlshamn and consists of an unsorted sandy deposit. It is found in the eastern part of the site, where the thickness of Quaternary deposits is much smaller than further westwards, where the bed-rock dependent valley is located.

The lowermost stratum is interpreted as a till. Stratum 1f 4 is related to the deglaciation of the area and is thus considered to be of glacio-fluvial origin. As this stratum is thickest in the middle part of the valley, it is likely that this valley also acted as a drainage passage during the deglaciation. Stratum 1f 3 is interpreted as being a varved clay and thus synchronous with the local varve chronology. The reason why silt dominates the lowermost part of this stratum can be explained by the presence of thick bottom varves. The dominance of clay in the rest of this stratum is probably due to deposition in deep water. Stratum 1f 2 is interpreted as redeposited fluviatile material, transported from higher to lower altitudes during the regression of the Baltic Ice Lake. The gyttja of stratum 1f 1 is probably a local lacustrine sediment formed in the river valley, and the high organic content shows that it is of post-glacial origin.

8.1.7. Lithostratigraphy of the Mieå river valley

The strata from sites 1a to 1f have been grouped in a stratigraphic table shown in Fig. 55. The lowermost unit, Hoka till, represents the glaciation as well as parts of the deglaciation of the area and can be correlated with the till deposits surrounding the river valley as well as the till found in Karlshamn. The name Hoka comes from a small village located north of Långasjön, where till is the dominant deposit. Norrefors gravel and sand is correlated with strata found at five of the six described sites. All these strata are interpreted as being of glaciofluvial origin, thus representing the deglaciation of the valley. As the southernmost sites became ice-free earlier than the more northerly located sites (Ringberg, 1971 and 1979) this unit is metachronous within the valley. But at each site this unit represents the deglaciation of that particular

Stratigraphic units of the Mieå river valley	Dannemark 1a	Norrefors 1b	Jepshoka 1c	Tararp 1d	Hanamo 1e	Karlshamn 1f
Karlshamn gyttja						1f 1
Hinseberget silty sand						1f 2
Hanamo sand				1d 1	1e 1	
Tararp gravel & sand				1d 2	1e 2	
Tararp sand & silt				1d 3	1e 2	
Tararp silt & clay				1d 4	1e 3	1f 3
Norrefors gravel & sand	1a 1 1a 2 1a 3 1a 4	1b 1 1b 2	1c 1 1c 2 1c 3	1d 5		1f 4
Hoka till						1f 5

Fig. 55. Lithostratigraphic units of the Mieå river valley related to the described strata.

site. Norrefors has been chosen as a type site for this unit, as large parts of the valley are characterized by the occurrence of this type of eskers. As is clear from Fig. 55 the Tararp silt and clay is not found north of site 1d. This unit is regarded as a more or less synchronous unit representing the varved clay in Blekinge. In Tararp this unit is interpreted as a bottomset bed in a delta, while in Karlshamn it is supposed to be a distal deep water sediment. As site 1f became ice-free earlier than site 1d, a part of the glaciogenic varved sedimentation is absent at Tararp. The Tararp sand and silt unit represents an incomplete foreset bed in a delta, which together with the Tararp gravel and sand is almost exclusively found in this part of the valley. The more distal deposits of these units are found in Hanamo. These two units seem to be related to the final phase of the formation of a delta, and the Tararp gravel and sand shows that the water level was not

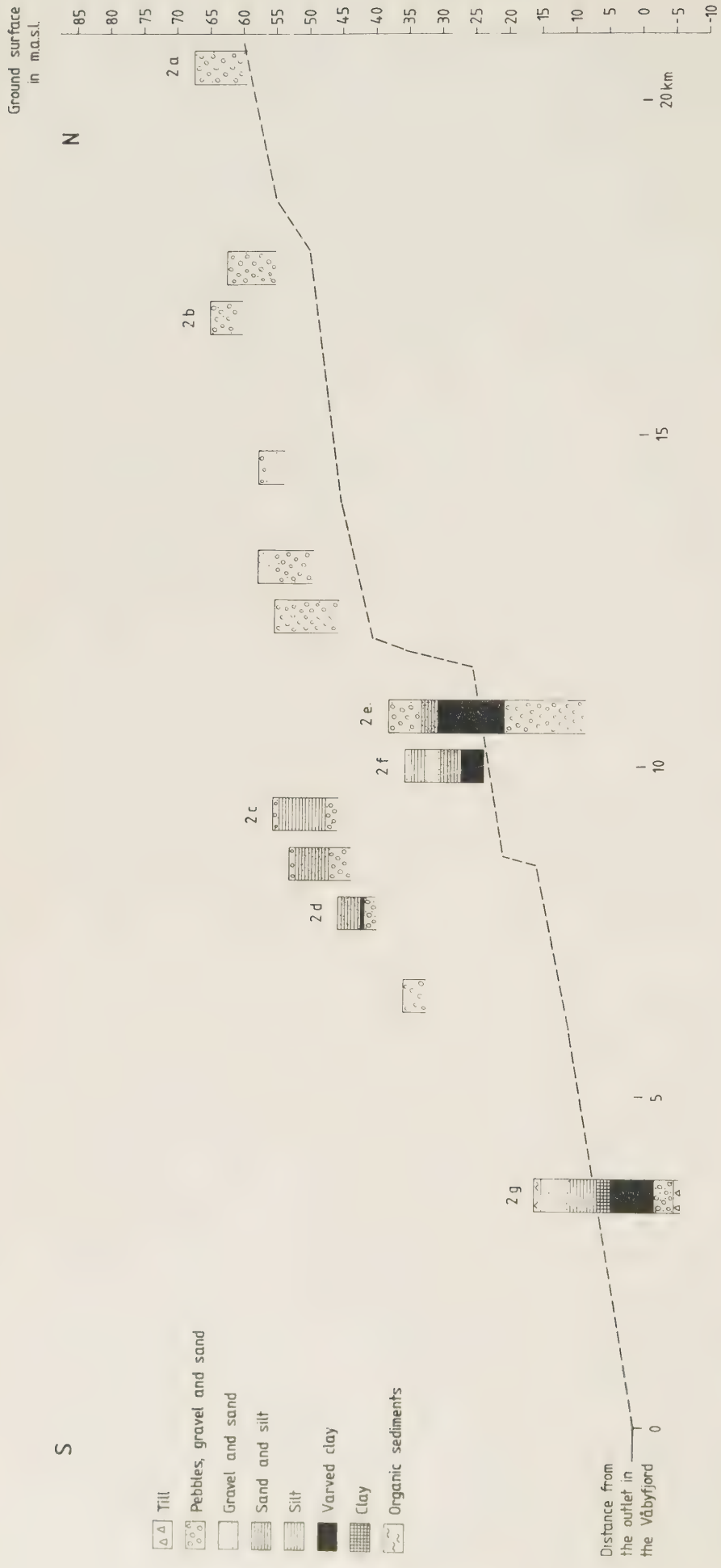


Fig. 56. A profile of the southern part of the Bräkneå river valley. The lithostratigraphy derives from gravel pits and bore-holes and site 2a to 2g are further described in the text. The dotted line represents the altitude of the Bräkneå river.

higher than 55 m a.s.l. when this unit was formed. If the boundary between the topset bed and the foreset bed does not represent a long hiatus, the topset bed is not very much younger than the Tararp silt and clay unit, which is a part of the local varve chronology. The Hanamo sand represents deposits formed mainly during the regression of the Baltic Ice Lake by wave-washing of till and sorted sediments. This type of deposit is usually found near to the valley slopes. The Hinseberget silty sand also represents a deposit directly related to the regression. This unit was formed by fluvial redistribution of material from higher to lower altitudes. This took the form of erosion at higher altitudes and accumulation at lower, which went on as the regression reached lower altitudes, and thus the youngest parts of this unit are found at the lowest altitudes above the sea level. The Karlshamn gyttja represents the sedimentation during the Holocene, which in a lacustrine environment is usually characterized by comparatively high organic production caused by the temperature amelioration.

8.2. The Bräkneå river valley (2)

This river (Fig. 51) drains four rather large lakes in Småland situated just southeast of Lake Åsnen. These lakes are situated 40 to 50 km from the coast in Blekinge. The size of the drainage area is 458 km². The river valley is narrow and deep north of Björkeryd (Fig. 2) with the exception of the northernmost part. The direction of the valley is usually NNW-SSE. Just south of Björkeryd the valley is separated into two wider valleys. The western one passes Stenkulla and Muggeboda, while the eastern valley, where the Bräkneå river is today situated, passes Tararp and Rödby and joins the western one at Dönhult. The river passes west of Bräkne-Hoby, and its mouth is located in the Våbyfjord 7 km south of Bräkne-Hoby.

18 sites have been investigated in this valley, 7 of which are described in this work. A profile of the river has been constructed (Fig. 56) together with the lithostratigraphy at some of the sites.

8.2.1. Hålabäck (2a)

This site is located 500 m south of Hålabäck (Fig. 51). It is an

oval-shaped gravel pit, its well-defined formation produced by considerable slopes. The size is 200 x 100 m, and the upper flat surface is situated between 65 and 70 m a.s.l. The valley is extremely wide at this site.

The sediments at Hålabäck have been put together to form one stratum (2a 1).

- 2a 1 This stratum, the only one recorded from Hålabäck, consists of pebbles, gravel and sand. It is poorly stratified but rather well sorted. The pebbles and the gravel are well rounded. The thickness of this stratum is at least 5 m.

This formation is interpreted as a kame, which is supported by the presence of ice-contact slopes surrounding the whole formation. The water flow must have been considerable. The surrounding ice was probably not dense enough to create a small ice-dammed lake.

8.2.2. Sävsjömåla (2b)

This site is located at Sävsjömåla just east of the Bräkneå river and 1 km SSE of Örseryd (Fig. 51). Between Örseryd and site 2a a very marked ridge follows the western river shore. This ridge is interpreted as an esker. The formation at Sävsjömåla consists of a rather flat plateau, 400 x 400 m large, well-defined to the west, the east and to the south by steep slopes. Large round depressions and rather wide channels are common at the top surface of the formation. This surface is situated between 60 and 65 m a.s.l.

The sediments, which have been studied in two gravel pits, are divided into two strata (2b 1 - 2b 2).

- 2b 1 This stratum is the uppermost recorded at Sävsjömåla and consists mainly of pebbles and gravel with some thin laminae of sand. It is usually poorly stratified, but some sandy and gravelly laminae show that the material is cross-bedded with cut and fill structures. This stratum is sometimes very disturbed. These disturbances are most common at the slopes, which delimit the formation. The thickness of this stratum is about 4 m and the

lower boundary is very distinct.

- 2b 2 This stratum consists of well sorted sand with cross-lamination. The stratification is horizontal. The thickness of this stratum is at least 1 m.

This formation is interpreted as a kame delta, formed between bodies of ice. The slopes, delimiting the formation, are interpreted as ice-contact slopes, and the disturbances in stratum 2b 1 were probably caused by collapse when the surrounding ice finally melted. Stratum 2b 2 is interpreted as being deposited in an ice-dammed lake, while stratum 2b 1 represents sedimentation at or above water level.

8.2.3. Muggeboda (2c)

This site lies in the western valley at Muggeboda (Fig. 51), just between Vasakull and Lillagärde, 4 km NNW of Bräkne-Hoby. The road from Stenkulle to Muggeboda is situated on a very marked ridge. At Muggeboda this ridge changes to a much wider plateau, 150 x 200 m in size and situated about 50 m a.s.l. The surface of this formation is, with the exception of the ridge in the eastern part of the plateau (Fig. 57) and some circular depressions in the western part, relatively flat. This formation is separated from the surroundings by very steep slopes. The stratigraphy of this site represents investigations in a large gravel pit.

The sediments at Muggeboda have been divided into four strata (2c 1 - 2c 4).

- 2c 1 This is the uppermost stratum recorded from Muggeboda, and it consists of poorly stratified gravel and sand. This stratum is disturbed at some places by collapses originating from underlying strata. The thickness of this stratum is about 0.5 m and the lower boundary is distinct.
- 2c 2 This stratum consists mainly of fine sand (Fig. 60). Plane bed-lamination is found in the uppermost part of the stratum, while cross-lamination is found further down. The sets usually dip gently, but quite often this stratum is disturbed by collapses. The thickness of this material



Fig. 57. The gravel pit at Muggeboda seen from the south. To the right the esker is situated, while the rather flat delta surface is situated to the left in the background.



Fig. 58. The laminated sand and silt of stratum 2c 3 overlying exploited pebbles and gravel belonging to the esker. In the background can be seen the flat surface of the delta. Photographed from the north.

varies between 2 and 4 m. Dip and orientation analyses show that the material was transported from NNW. The lower boundary is gradual.

- 2c 3 This stratum consists of horizontally laminated fine sand and silt (Fig. 58). Climbing ripples are common, especially in the fine sand. Folds and other types of disturbances (Fig. 59) are very common near to the contact with the easterly situated ridge, but also occur away from the ridge. Redeposited clay has been found in the lowermost part of this stratum. The thickness of the stratum varies between 3 and 5 m. The lower boundary is very distinct.
- 2c 4 This stratum, the lowermost recorded from Muggeboda, consists of boulders, pebbles, gravel and sand. The ridge described above (Figs. 57 and 58) belongs to this stratum. The upper part of this ridge consists of cross-bedded gravel and sand, while boulders and pebbles dominate the centre of the ridge. The material in the western part of the ridge is always very disturbed, usually by extensive collapses, which have also disturbed the overlying strata. This stratum has also been found in the western part of the gravel pit, where it has a flat extension in the bottom of the gravel pit (Fig. 60). As it is a very coarse material, any kind of stratification is hard to distinguish. Plane bed-lamination has, however, been observed in some gravel laminae. Collapses have also been found in this horizontally spread coarse material. Whether this material belongs to the same deposit as the ridge or not cannot be determined with certainty, as it has been impossible to find the contact between these two morphological features. The thickness of this stratum is at least 10 m at the ridge and at least 2 m in the western part of the gravel pit.

Stratum 2c 4 is interpreted as being glacio-fluvial deposits, with the described ridge interpreted as an esker formed in a tunnel or a fissure in the ice. This is supported by the presence of extremely steep slopes surrounding the ridge in the gravel pit as



Fig. 59. Disturbances in stratum 2c 3 in the western part of the site.



Fig. 60. The northwestern part of the gravel pit seen from the south. To the left the sand of stratum 2c 2 can be seen at the top with disturbances, caused by collapse, to the right. At the bottom of the gravel pit the coarse material with flat extension can be seen belonging to stratum 2c 4.

well as north and south of it. These slopes are interpreted as ice-contact forms. The flat part of this stratum can be interpreted in different ways. One possibility is that it was formed sub-glacially. But this is partly contradicted by the existence of the esker, which must have served as the drainage channel of this valley during the deglaciation. This material could also have been deposited subaqueously and very proximally with a high velocity of the transporting water. However, with an interpretation like this, one would expect a transitional sediment between the very coarse material and the silt. On the contrary the boundary between these two strata is very distinct. A third possibility is that the material was deposited in a subaerial environment as an outwash plain. Such an explanation also presents problems, as e.g. the fact that this plain must then have been formed almost completely surrounded by ice, as the overlying strata are restricted by ice-contact surfaces. This "hole" in the ice could, however, have been open to the south, where site 2d lies. The extensive disturbances in this stratum were probably caused by collapses of surrounding ice as well as buried ice within and/or beneath this stratum. The effect of these collapses on the overlying strata show that most of the material at Muggeboda was deposited before the buried ice finally melted. Stratum 2c 3 is interpreted as a bottomset bed in a kame delta, and if the horizontal part of stratum 2c 4 is an outwash plain, a transgression must have taken place between these two strata. The redeposited clay in the lowermost part of stratum 2c 3 indicates that clay could be missing between strata 2c 4 and 2c 3 because of erosion. The fact that stratum 2c 3 is laminated indicates that it is a continuation of varved clay. Stratum 2c 2 is interpreted as a foreset bed and thus a natural continuation of the underlying strata in a delta sequence. The dip and orientation analyses show that only one transport direction prevails in this stratum. Stratum 2c 1 completes the delta, as it is interpreted as a topset bed, which means that this stratum would have been deposited at or above water level.

8.2.4. Hjalmsa (2d)

This site is located about 1 km south of site 2c at the widest part of the western valley (Figs. 51 and 56). The middle part of this valley is dominated by the continuation of the esker described at

site 2c. The gravel pit investigated lies in a flat plain situated about 45 m a.s.l. The esker passes through the eastern part of the gravel pit.

The sediments at Hjälmssa have been divided into three strata (2d 1 - 2d 3).

- 2d 1 This stratum, the uppermost recorded from Hjälmssa, consists of sand and silt. The sets, which dip slightly to the south, are small scale cross-laminated and are thus formed by ripple migration. The thickness of this stratum varies between 3 and 4 m.

- 2d 2 This stratum consists of thin silt and clay laminae. Its thickness is 0.3 m. The lower boundary is distinct.

- 2d 3 This is the lowermost stratum from Hjälmssa. It consists of gravel and pebbles. The gravelly parts of this material are cross-bedded, while the stratification in the coarser material is harder to distinguish. Structures reminiscent of cut and fill structures have been found in the western part of the gravel pit. With the exception of the esker, this coarse material has a marked horizontal extension. It is not known if the esker and the rest of this material belongs to the same stratum, as the esker has been almost completely quarried. The thickness of the horizontally extended material is at least 2 m.

As at Muggeboda it is possible to interpret the lowermost stratum in different ways. But stratum 2d 3 is much more wide-spread than stratum 2c 4. This makes it appear like an outwash plain. Stratum 2d 2 is a varved clay and thus a distal deposit of the melting ice. Stratum 2d 1 is interpreted as a foreset bed, and thus a continuation of the varved clay, which probably originally was much thicker. The change in grain-size between these two strata can be explained by an increase in velocity of the transporting water caused by decreasing water depth and/or an increase of the amount of accessible melt-water. Unlike stratum 2c 1 at Muggeboda, no stratum has been found indicating sedimentation at or above a water level, completing the delta sedimentation. The site at Hjälmssa is, however,



Fig. 61. The exploited esker at Stenkulla south of the Bräkneå river seen from the south. The esker is cut off just north of this gravel pit.



Fig. 62. Stratum 2e 1 at Lindefors.

situated 10 m below Muggeboda, which could explain the absence of such a stratum.

8.2.5. Lindefors (2e)

This site lies just southwest of Tararp (Fig. 51) in the eastern valley, where the Bräkneå river is situated today. This area is characterized by the very deep valley to the west and a flat surface east of the valley situated between 35 and 40 m a.s.l. While the western valley is distinguished by the very marked esker, this valley is characterized by a very even topography, with the exception of the northernmost part between Stenkulla (Fig. 61) and Tararp, which is extremely narrow and deep. This site lies just where the valley widens. The stratigraphy from this site originates from a gravel pit, and results from seven borings carried out by Blomberg and Ohlsson (1979).

The sediments from the Lindefors area have been divided into four strata (2e 1 - 2e 4).

- 2e 1 This is the uppermost recorded stratum from Lindefors, and it consists of pebbles, gravel and sand (Fig. 62), with gravel as the dominant grain-size fraction. The material is cross-bedded with very distinct foresets. This stratum is only found east of the river and seems to be restricted north and eastwards by a small ridge. The thickness of this stratum does not exceed 5 m. Dip and orientation analyses show that the material was transported from the northwest, and in some cases from the north as well as from the west. The lower boundary is distinct.

- 2e 2 This stratum consists of fine sand and silt. The upper part of the stratum is dominated by fine sand, while the lower part consists of silt, interbedded with some clay laminae. This stratum is common in the area, and the thickness varies between 2 and 3 m. The lower boundary is gradual.

- 2e 3 This stratum consists of laminated silt and clay. The

bottommost part usually consists of relatively thick silt or fine sand laminae. The clay laminae are usually reddish brown, while the silt is grey. At one boring 528 laminae were counted, and the thickness of the stratum at this boring is 10.2 m.

- 2e 4 This is the lowermost stratum in the Lindefors area. It consists of boulders, pebbles, gravel and sand. Gravel and sand seem to characterize the upper part of this stratum, while it is much coarser downwards. This stratum has once been found underlying stratum 2e 3. The boundary between these two strata at this boring point seems to be gradual. At a bore-hole on the small ridge mentioned in connection with stratum 2e 1, 12.5 m of stratum 2e 4 was found without being either overlain or underlain by any other stratum. At borings 150 m east and 200 m west of this point stratum 2e 4 is not found.

Stratum 2e 4 is interpreted as being a glacio-fluvial material, deposited during the deglaciation. The small ridge belonging to this stratum is probably a type of esker, and if so it is the only esker found in the eastern valley. Stratum 2e 3 is interpreted as being varved clay, deposited in still and relatively deep water. The presence of 264 varves in this area fits very well with the local varve chronology established by Ringberg (1979). The lowermost coarser part of this stratum is very likely the bottom varves and thus represents the transition from a glacio-fluvial to a glacio-lacustrine sedimentation. As the varves in Blekinge are usually very thin at the top of the varve series, stratum 2e 2 must have a local explanation. The large change in sedimentation that this stratum shows is interpreted as a change in the main drainage of the Bräkneå river valley. This is supported by the fact that the western valley most probably functioned as the main drainage passage during the deglaciation of the valley (sites 2c and 2d). The esker described in connection with sites 2b, 2c and 2d and shown in Figs. 57, 58 and 61 is completely cut off by the river, where the valley is separated into two different valleys. Whenever this drainage change happened, it possibly caused a considerable change in sedimentation rate in parts of the western valley, at least for a short period of time. Stratum 2e 1 is interpreted as a fluvial sediment deposited in shallow water

during the regression. This material most likely originates from adjacent glacio-fluvial deposits, as e.g. the esker described in connection with stratum 2e 4, and redeposited by fluvial erosion and accumulation.

8.2.6. Rödbý (2f)

This site lies between Tararp and Rödbý, just northeast of Lilla-gärde on the eastern side of the river (Fig. 51). Like site 2e it is characterized by even topography situated about 35 m a.s.l. This surface is partially cut through by the Bräkneå river and partially by a small stream in the eastern part of the area. The stratigraphy from the Rödbý area originates from detailed studies in two gravel pits and from four borings carried out by Blomberg and Ohlsson (1979).

The sediments from the Rödbý area have been divided into five strata (2f 1 - 2f 5).

- 2f 1 This stratum, the uppermost recorded from Rödbý, consists of gravel and sand (Fig. 63). In the easternmost part of the area this stratum consists of fine sand. This material is usually very loosely packed and seems to completely lack any kind of structures. The thickness varies between 0.5 and 1.0 m. The lower boundary is relatively disturbed and very distinct.

- 2f 2 This stratum consists of extremely firmly packed silt (Fig. 63). It is slightly laminated, but this lamination is usually very hard to distinguish. The thickness of this stratum varies between 0.0 and 0.5 m and the lower boundary is very distinct.

- 2f 3 This stratum consists of gravel and sand (Fig. 63). The uppermost part of this stratum is characterized by cross-bedding with very distinct foresets, while the lower part is poorly stratified. The thickness of this stratum reaches at most 2.5 m, and it is only found near to the river. Dip and orientation analyses show that the material was transported from the northwest. The lower



Fig. 63. Strata 2f 1 - 2f 4 at Rödbý. The light horizon of packed silt is overlain by the structureless gravel and sand and underlain by cross-bedded gravel and sand.

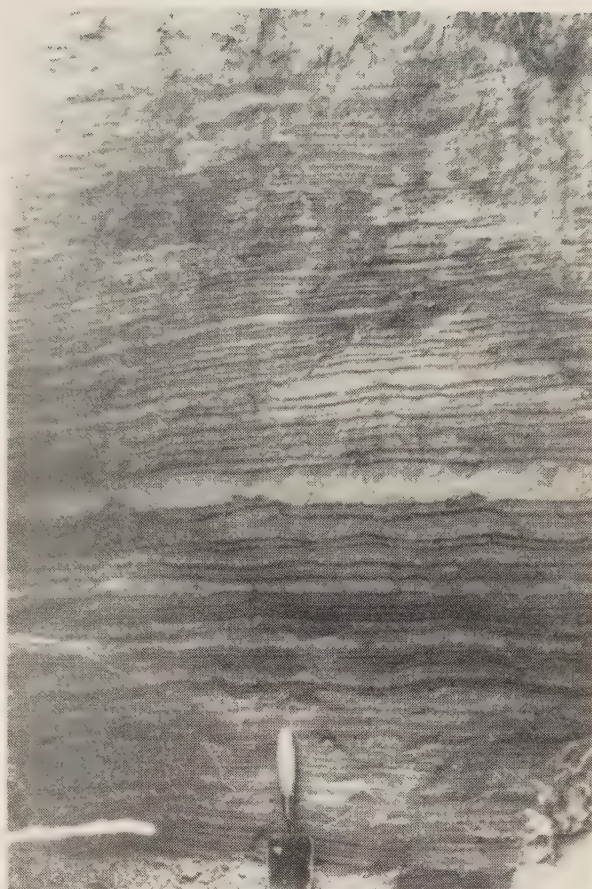


Fig. 64. Stratum 2f 5 at Rödbý showing the 127 varves measured.

boundary is very distinct.

- 2f 4 This stratum consists of fine sand and silt (Fig. 63), interbedded with some thin clay laminae. The silt and fine sand is plain-laminated. A thickness of 3 m of this stratum has been found. The lower boundary is gradual.
- 2f 5 This is the lowermost stratum recorded from the Rödbý area, and it consists of laminated silt and clay (Fig. 64). The thickness of this stratum is not more than 4.5 m, but even so 410 laminae have been counted, 254 of which have been measured in the open section shown in Fig. 64. This stratum is underlain by boulders or bed-rock.

Stratum 2f 5 is interpreted as being a varved clay deposited in deep water. Although the number of varves does not differ very much from the number found at Lindefors, the thickness between strata 2f 5 and 2e 3 differ very much. This means that the varves of stratum 2e 3 are considerably thicker. The varves measured from Rödby have been correlated with the local varve-chronology, and the 127 uppermost varves start at the local year + 167 and end at the local year + 294. Stratum 2f 4 is thought to be a continuation of the varved clay, but with a drastic change in sedimentation, caused possibly by a change in the drainage pattern in the Bräkneå river valley. This interpretation was discussed in more detail in connection with site 2e. Stratum 2f 3 indicates fluvial deposition in a shallow water. The comparatively coarse material probably originates from glacio-fluvial deposits situated upstream. The silt belonging to stratum 2f 2 is, however, hard to explain. The very sudden change in grain-size can be explained by increasing water depth or by a radical change in flow, perhaps only very locally. It is also possible to interpret it as a turbidite, which according to Shaw and Archer (1978) can be more or less structureless. However, the certain origin of this stratum cannot be determined, which is probably due to the very complex environment at a river mouth during a regression. Stratum 2f 1 is interpreted as being redeposited material, formed by a mixture of wave-washing and fluvial erosion and accumulation just before the area emerged out of the Baltic Ice Lake.

8.2.7. Hakarp (2g)

This site represents the flat land south of Bräkne-Hoby, situated between 10 and 15 m a.s.l. (Figs. 51 and 56), through which the Bräkneå river passes. The stratigraphy of this area has been mainly derived from borings carried out by Schneider (a German student). Most of these borings have been made in the area delimited by the following villages: Evaryd, Hobykulle, Mörtjuk, Hakarp and Torp. Open sections have not been found within the area, which means that it has not been possible to study the different strata in detail.

The sediments from the Hakarp area have been divided into seven strata (2g 1 - 2g 7).

- 2g 1 This stratum, the uppermost recorded from Hakarp, consists of peat and gyttja. It is usually found by the river or in smaller depressions. The thickness of this stratum is usually not more than a couple of metres.
- 2g 2 This stratum consists of sand, and is most common in the vicinity of the river, but is also present in lower parts of the flat land. It reaches a thickness of almost 10 m at the river.
- 2g 3 This rather common stratum consists of silt and seems to be present in most parts of the area. The thickness of this stratum does not seem to exceed 5 m.
- 2g 4 This stratum consists of unlaminated clay and is always overlying stratum 2g 5. The thickness varies, but it is usually at least two metres thick. The lower boundary is gradual.
- 2g 5 This is the most common and thickest stratum within the area. It consists of laminated clay and silt. More than 500 laminae have been counted. In the upper part of this stratum it has been difficult to separate the different laminae from each other and thus the youngest laminae have not been measured. The thickness of this stratum varies from about 2 to 10 m.
- 2g 6 This stratum consists of gravel and sand. It is usually found on the slopes of bed-rock dependent ridges, overlain by stratum 2g 5. Its thickness is at most 5 m.
- 2g 7 This stratum is the lowermost recorded from this area and it consists of an unsorted material, with a thickness of at least 1 m.

Stratum 2g 7 is interpreted as till, deposited during the glaciation of the area. Stratum 2g 6 is interpreted as being a glacio-fluvial deposit and is thus related to the deglaciation. The morphology of this deposit is not known sufficiently to tell what kind of formation it belongs to. Stratum 2g 5 is interpreted as being a varved clay and Schneider has correlated it with Ringberg's (1979) local

varve chronology and found that the oldest varve in Hakarp corresponds to the local year -60, which is in good agreement with Ringberg's equicesses. This stratum was deposited as a deep water sediment progressively distant from the retreating ice, with its cyclic influence on the sedimentation. The clay of stratum 2g 4 is interpreted as a continuation of the varved clay, but without any glaciogenic influence. This change in sedimentation is important, and it suggests that the glaciogenic lacustrine sedimentation was followed by a noncyclic lacustrine phase. The amount of material deposited during this latter deep water stage seems to have been much smaller than during the previous centuries, which were characterized by the melting of ice. Strata 2g 3 and 2g 2 are interpreted as redeposited fluvial material, transported from higher to lower altitudes during the very last part of the regression of the Baltic Ice Lake. Possibly parts of stratum 2g 2 are made up by material formed by wave-washing during the regression, but this stratum is impossible to divide further as all the observations originate from borings. The gyttja of stratum 2g 1 represents Holocene lacustrine sedimentation, while the peat represents overgrowth in a shallow basin during the same time.

8.2.8. Lithostratigraphy of the Bräkneå river valley

The strata from the seven different sites in the Bräkneå river valley have been grouped in a table (Fig. 65) and divided into eight stratigraphic units. The lowermost unit, Torp till, represents the glaciation of the river valley, which means that all till in the area can be correlated with this unit. The Sävsjömåla gravel and sand is found at six of the seven sites. Besides gravel and sand this unit is often characterized by boulders and pebbles. It represents all deposits formed by glacio-fluvial activity during the deglaciation of each site, which means that this unit is metachronous. Different types of formations belong to this unit, and thus the environment in which this unit was formed changed from site to site. The Lindfors silt and clay represents the change to a glacio-lacustrine environment, with deposition of varved clay or silt. This means that this unit is related to sedimentation in deep water, forming e.g. a bottomset bed in a delta as is the case at site 2c. The Hjälmsa sand and silt represents the foreset bed of a delta, and is thus the natural continuation of the Lindfors silt and clay in a delta formation. The Muggeboda gravel and

Stratigraphic units of the Bräkneå river valley	Hålabäck 2a	Sävsjömåla 2b	Muggeboda 2c	Hjälmsa 2d	Lindfors 2e	Rödby 2f	Hakarp 2g
Evaryd peat & gyttja							2g 1
Rödby gravel, sand & silt					2e 1	2f 1 2f 2 2f 3	2g 2 2g 3
Hakarp clay							2g 4
Muggeboda gravel & sand			2c 1				
Hjälmsa sand & silt			2c 2	2d 1			
Lindfors silt & clay			2c 3	2d 2	2e 2 2e 3	2f 4 2f 5	2g 5
Sävsjömåla gravel & sand	2a 1	2b 1 2b 2	2c 4	2d 3	2e 4		2g 6
Torp till							2g 7

Fig. 65. Lithostratigraphic units of the Bräkneå river valley related to the described strata.

sand closes the delta sedimentation at Muggeboda as it is interpreted as a topset bed. These two last units have only been found in the western valley, which shows that this valley worked as the main drainage passage during the time these units were formed. The Hakarp clay is the first post-glacial unit in the area, and seems only to have been deposited south of Bräkne-Hoby, as the water depth was probably not great enough further northwards. This unit represents lacustrine sedimentation in the Baltic Ice Lake without any glacial influence. The Rödby gravel, sand and silt represents redeposition of material during the regression of the Baltic Ice Lake. This unit contains strata formed in a very complex environment, influenced by fluvial erosion and accumulation as well as by wave-washing. This complexity is very well illustrated at Rödby. Most likely the strata of this unit are younger the lower they are situated. The Evaryd peat and gyttja represents the high organic production during the Holocene, which is due to the climatic amelioration characterizing this stage.

8.3. The Ronnebyå river valley (3)

The Ronnebyå river (Fig. 51) drains an extensive area (1112 km²), of which a major part lies in Småland, with Lake Rotten as the largest lake within the drainage area. The length of the area is about 85 km. From the border between Blekinge and Småland and down to Kallinge the river valley is usually narrow and orientated from NNW to SSE. Northwest of Kallinge the famous Bredåkra delta is located (e.g. Andersson 1927, Ringberg 1971, Hebrand 1978). South and southwest of Kallinge the river valley widens. The mouth of the Ronnebyå river lies southeast of Ronneby. The main reason that this valley has been previously well investigated is most likely due to the presence of the Bredåkra delta. All investigations concerning this formation have recently been summarized and also to some degree complemented by Hebrand (1978). This work represents a very useful attempt to summarize the stratigraphy of the deposits related to this formation. Fig. 66 is a generalized picture of the formation, with Hebrand's stratigraphic division of the deposits.

8.3.1. Skärvgöl (3a)

This site is located at the northern part of Lake Rötllången, 15 km north of Ronneby (Fig. 51). The area is characterized by the very pronounced fissure valley in which Lake Rötllången lies. The valley slopes are characterized by the presence of terraces, situated between 65 and 70 m a.s.l. A very marked ridge winds its way through the valley. Sometimes it appears as elongated islands in Lake Rötllången, while at other places it lies either west or east of the lake. The deep fissure valley is surrounded by a ground of uneven topography dominated by unsorted deposits and bed-rock. The stratigraphy from this site originates from investigations made by Hebrand (1978) in a gravel pit and its surroundings just southeast of Skärvgöl. The gravel pit lies in a hillock, situated between 70 and 75 m a.s.l., surrounded by a mantle which levels out the topography.

The sediments from the Skärvgöl area have been divided into three strata (3a 1 - 3a 3).

- 3a 1 This is the uppermost stratum recorded from Skärvgöl and it consists of stratified, well sorted gravelly sand. The mantle described above consists of this material. This is the material usually found in the terraces occupying the valley slopes. The thickness of this stratum varies between 1 and 2 m.
- 3a 2 This stratum consists of poorly sorted material, consisting of boulders, pebbles, gravel and sand. The material is usually horizontally stratified. This material, which the hillock is made up of, is very typical for the winding ridge described above.
- 3a 3 This stratum consists of an unsorted sandy material. It occurs commonly in the hillocky area surrounding the valley. The thickness does not usually exceed 3 m.

Stratum 3a 3 is interpreted as being till, deposited by inland ice during the glaciation and/or deglaciation of the area. Stratum 3a 2 is interpreted as being a glacio-fluvial material, belonging to an esker system deposited during an early phase of the deglaciation in a fissure or tunnel inside the ice. At that time the melt-water was concentrated in these fissures or tunnels, which can now be seen as well-defined eskers. Stratum 3a 1 is interpreted as being deposited during a later phase of the deglaciation. During this phase the ice occupied only the deepest parts of the valley, and the main drainage of the valley took place between the ice and the valley slope. Stratum 3a 1 is thus interpreted as belonging to kame terraces. The deglaciation of this area resulted in a kame landscape. These interpretations coincide with the interpretations made by Hebrand (1978).

8.3.2. Bredåkra (3b)

This site represents a rather extensive area, lying just northwest and west of Kallinge (Figs. 51 and 66). This area has been regarded by Blomberg (1927), Ringberg (1971) and Hebrand (1978) as a southern part of the Bredåkra delta. The area between the Bredåkra area and Lake Rötllången is characterized by a flat, very gentle southwards sloping surface interrupted by depressions, small valleys and hillocks of unsorted material and bed-rock. With

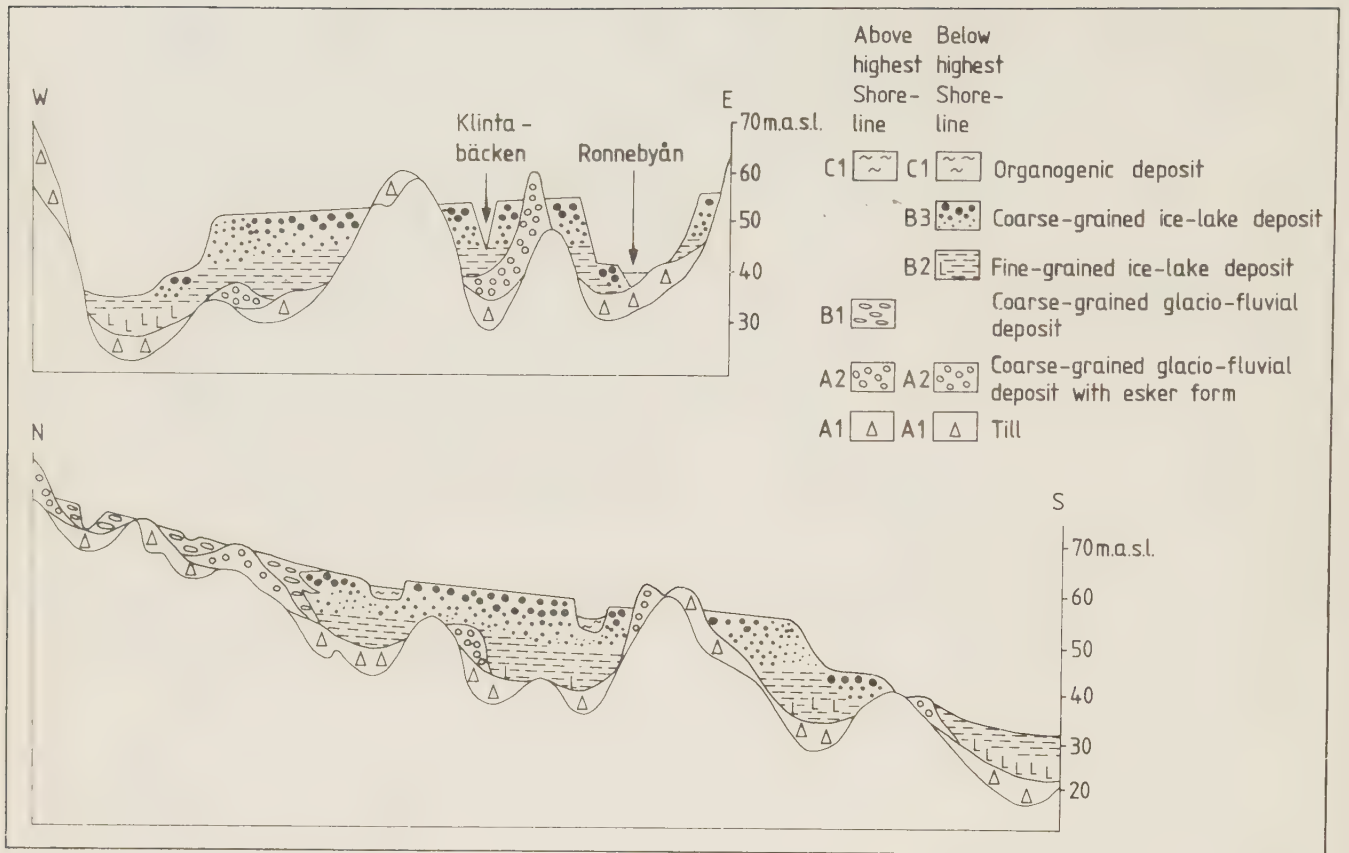


Fig. 66. A generalization of the lithostratigraphy of the Bredåkra area. (After Hebrand 1978)

the exception of the very many depressions and hillocks, this area is situated between 60 and 65 m a.s.l. The Bredåkra area is characterized by large flat surfaces, situated between 50 and 55 m a.s.l., which are sometimes interrupted by hillocks. Two small valleys orientated towards the southwest pass through the area. Southwards and westwards the area is restricted by a slope down to about 35 m a.s.l. The stratigraphy of this area originates mainly from Hebrand (1978), who has summarized all investigations in the area, including borings carried out by engineering companies for different purposes. I myself have made two borings in the area, together with investigations in the gravel pits available. Thus the stratigraphy from the Bredåkra area represents a synthesis of a large amount of material.

The sediments from Bredåkra have been divided into seven strata (3b 1 - 3b 7).

- 3b 1 This is the uppermost recorded stratum from the Bredåkra area, and it consists of peat. It usually lies in small hollows. The thickness of this stratum does not exceed 3 m.
- 3b 2 This stratum consists of horizontally stratified pebbles, gravel and sand. In the northern and northeastern part of the area this stratum is coarser than further southwards. The thickness of this stratum is usually between 1 and 2 m. The lower boundary is usually distinct.
- 3b 3 This stratum consists of cross-bedded or cross-laminated gravel and sand, with sand as the dominant grain-size. The thickness of this stratum varies between 2 and 10 m. The sets of this material dip towards the west or the south (Fig. 67). The lower boundary is gradual.
- 3b 4 This stratum consists of horizontally stratified silt (Fig. 67), interbedded with clay laminae, especially in the lower part of the stratum (Figs. 69 and 70). Cross-lamination formed by ripple migration is common. In the very eastern part of the area this stratum is 19 m thick. According to Ringberg (1971, p. 136) a boring at Skarup, situated in the very western part of the area, shows a transition from varved clay to silt with clay laminae. This suggests that the lower boundary of this stratum is gradual.
- 3b 5 This stratum consists of thin silt and clay laminae. Except for the boring at Skarup, this stratum has only been found once, at a boring carried out by myself just south of the airport. The Skarup boring shows that the silt, containing about 75 clay laminae, is underlain by 54 varves, which have been linked with the varves just pre-dating the diffuse varve type (Ringberg, 1971). The bore-hole south of the airport showed the existence of at least 60 laminae underlying sand and silt, with brown clay laminae and grey silt laminae. From this boring it appears that the lower boundary of this stratum is not very distinct.



Fig. 67. The gradual transition from stratum 3b 4 (B2) to stratum 3b 3 (B3) in the very western part of the delta seen from the south. (Photo M. Hebrand)



Fig. 68. The sharp-edged esker situated just northeast of Kallinge seen from the north. (Photo M. Hebrand)

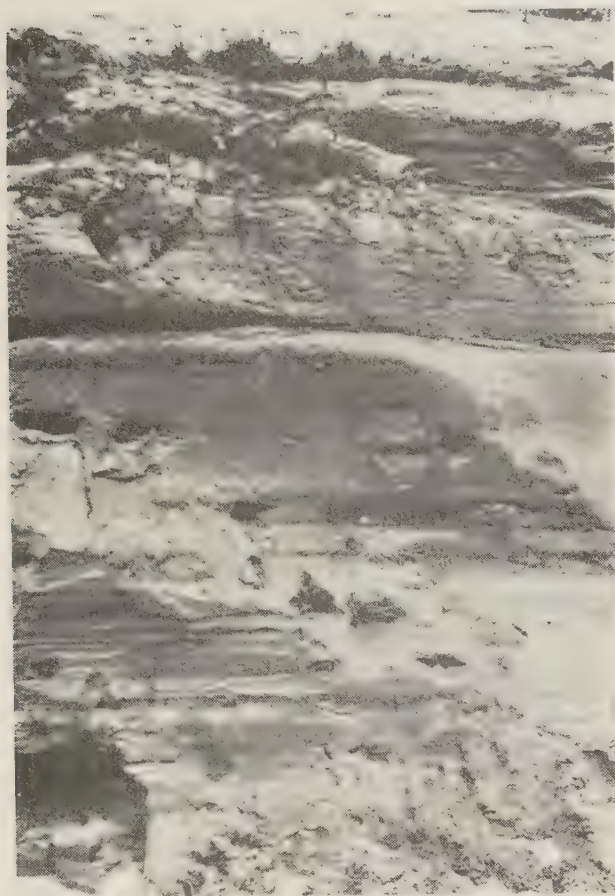


Fig. 69. Stratum 3b 4 in the eastern part of the area. The coin marks a clay lamina.

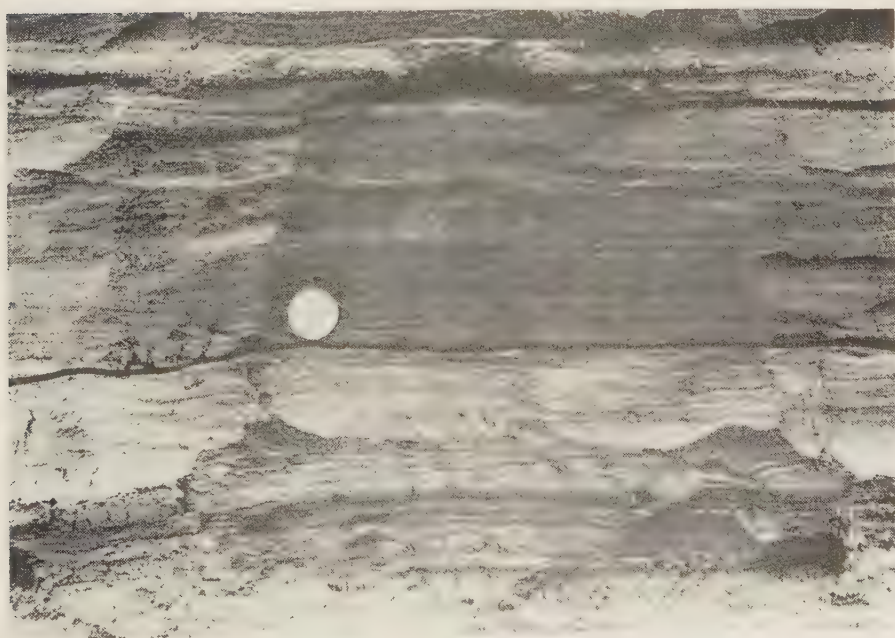


Fig. 70. A clay lamina (see Fig. 69) in stratum 3b 4, marked by a black line.

- 3b 6 This stratum was found in the bore-hole south of the airport, and it consists of gravel and sand underlying stratum 3b 5. The thickness of this stratum is at least 0.2 m.
- 3b 7 This stratum consists of a sandy unsorted material and is only found in hillocks penetrating the flat surface of the area. It is not more than a couple of metres thick.

Stratum 3b 7 is interpreted as being till, deposited during the glaciation and/or deglaciation of the area. Stratum 3b 6 is thought to be a glacio-fluvial deposit, formed during the deglaciation of the valley. An esker lies 1 km northeast of Kallinge (Fig. 68), but whether it belongs to such a formation or not is unknown. The fact that stratum 3b 6 is overlain by stratum 3b 5 shows that the deglaciation was followed by undisturbed glacio-lacustrine sedimentation, depositing varved clay, which stratum 3b 5 is interpreted as representing. Stratum 3b 4 is interpreted as being a bottomset bed in a delta, which is succeeded by stratum 3b 3 which is thought to be a foreset bed. The varves at Skarup, situated just distally to the delta, show that it is possible to correlate, at least partly, strata 3b 4 and 3b 3 with the deposition of the diffuse varve type in Blekinge. Stratum 3b 2 is interpreted as a topset bed formed at about the same altitude as the contemporary water level during the formation of this stratum. If the interpretation of these three last strata is correct, it means that the Bredåkra delta is a mature aggraded delta. The peat of stratum 3b 1 most likely represents the over-growth of small basins in the area during the Holocene.

8.3.3. Sörby (3c)

This site is located 2 km NW of the church of Ronneby and 3 km south of site 3b (Fig. 51). The 0.5 km wide valley, in which site 3c lies, is characterized by fine-grained sediments surrounded by 20 m high bed-rock slopes. The stratigraphy of this site originates from investigations carried out by Ringberg (1971).

The sediments from Sörby have been divided into two strata (3c 1 - 3c 2).

- 3c 1 This stratum, the uppermost recorded from Sörby, consists of thin silt and clay laminae. 562 laminae have been measured, and Ringberg (1971) has divided the stratum into four parts with respect to the thickness and appearance of the laminae. The thickness of this stratum is about 2 m and the lower boundary is gradual.
- 3c 2 This stratum consists of gravel and sand, and the transition to stratum 3c 1 consists of sand. The morphology of this stratum is indistinct.

Stratum 3c 2 is interpreted as being of glacio-fluvial origin, deposited during the deglaciation of the area. It is not possible to decide what kind of formation this stratum belongs to. Stratum 3c 1 is interpreted as being varved clay. The 281 varves have been linked with the varve chronology in Blekinge by Ringberg (1971), and this shows that the diffuse varves start about 150 varves from the bottom and last for at least 70 years. The boundary between these two strata represents the transition from a glacio-fluvial to a glacio-lacustrine environment. 40 to 50 years after this boundary the ice was situated at site 3b. These interpretations were made by Ringberg (1971).

8.3.4. Lithostratigraphy of the Ronnebyå river valley

The strata from sites 3a, 3b and 3c have been grouped in a table, related to the stratigraphic units of the Ronnebyå river valley (Fig. 71). During the following description these units will be compared with the division established by Hebrand (1978), which is shown in Fig. 66. The Ronneby till (A1) represents the glaciation and parts of the deglaciation of the valley. The Skärvgöl gravel (A1 and B1) represents the deglaciation of the area. At Skärvgöl this unit corresponds to two phases of the deglaciation, with each phase related to a separate formation. The esker is more or less synchronous with the older parts of the varved clay in the area, while the kame terraces were probably formed at about the same time as the delta was built up further southwards. This is the reason why Hebrand regards stratum 3a 1 (B1) as belonging to the delta formation. But although there could be a relatively long time interval between stratum 3c 1 and stratum 3c 2, they belong to the same stratigraphic unit as they represent a common

Stratigraphic units of the Ronnebyå river valley	Skärvgöl 3a	Bredåkra 3b	Sörby 3c
Kallinge peat		3b 1	
Bredåkra gravel & sand		3b 2	
Bredåkra sand		3b 3	
Bredåkra silt & clay		3b 4 3b 5	3c 1
Skärvgöl gravel	3a 1 3a 2	3b 6	3c 2
Ronneby till	3a 3	3b 7	

Fig. 71. Lithostratigraphic units of the Ronnebyå river valley related to the described strata.

depositional environment. The Bredåkra silt and clay (B2) represents deposition of deep water sediments, with the formation of varved clay as well as the formation of a bottomset bed in a delta. The Bredåkra sand (B3) is the continuation of the underlying unit where a bottomset bed has previously been deposited, and does thus represent the foreset bed in a delta. The Bredåkra sand (B3) is the continuation of the underlying unit where a bottomset bed has previously been deposited, and does thus represent the foreset bed in a delta. The Bredåkra sand and gravel (B3) represents the topset bed, and as such the end of the delta formation at site 3b. At least the bottomset bed and possibly parts of the foreset bed are considered to be more or less synchronous with the diffuse

varves found at e.g. Sörby. The reason for this interpretation is that this varve type seems to represent an increasing sedimentation rate as well as deposition of slightly coarser material. This interpretation is also supported by the varve stratigraphy at Skarup as well as the fact that this varve type is best represented at localities situated near to e.g. the Bredåkra delta and the Rödbý delta (Ringberg, 1971). This interpretation of the diffuse varve type was presented by Mörner 1974 and later by Ringberg (1979). If big parts of the Bredåkra delta is linked with the diffuse varves, it means that the major part of the delta was formed during a period of about 75 years. The existence of a topset bed in the delta shows that this bed was formed near to a water level. The Kallinge peat represents the favourable conditions during the Holocene compared with the relatively severe climate during the Late Weichselian.

8.4. The Åbyå river valley (4)

This stream valley is the easternmost river valley in Blekinge with a north-southerly direction (Fig. 51). The drainage area of this stream is 66 km². The northernmost part of the area is dominated by gentle hilly country with small basins filled with peat. Further southwards, 2 km north of Jämjö, the stream is located in a more pronounced valley called Ådalen. From 1 km north of Jämjö and southwards the stream has cut a deep valley through the very flat sediment plain (10-15 m a.s.l.), surrounded by bed-rock and till. South of Jämjö the stream is situated about two metres below the plain which dominates the landscape down to the Baltic.

All investigations in this valley were originally carried out by Möller (1976). This was later complemented and published by Björck and Möller (1976) and later also summarized by Björck and Möller (1977). All descriptive illustrations concerning this valley have previously been published in these works. The investigations have been concentrated in the area between Jämjö and Marielund. This area is represented by three sites.

8.4.1. Norrgård (4a)

This site (Fig. 51) consists of a rather restricted area located between Marielund and Kråkerum. It is characterized by a plain situated between 30 and 35 m a.s.l., which is surrounded by till and bed-rock. The stratigraphy of this site is derived from three borings.

The sediments from the Norrgård area have been divided into three strata (4a 1 - 4a 3).

- 4a 1 This is the uppermost stratum and consists of silt interbedded with thin laminae of fine sand. The thickness of this stratum varies between 0.6 and 4.8 m. 0.5 m of silt with clay laminae was found in one bore-hole within this stratum.
- 4a 2 This stratum consists of laminated clay and silt. The uppermost part of this stratum is dominated by silt, while the lower part is dominated by clay. The thickness of this stratum is at most 2.5 m.
- 4a 3 This is the lowermost stratum recorded from the Norrgård area. It consists of pebbles, gravel, sand and silt, with silt as the dominant grain-size fraction. This material is usually poorly sorted. The thickness of this stratum recorded varies between 0.6 and 2.5 m.

Stratum 4a 3 is interpreted as being of glacio-fluvial origin, thus representing the deglaciation of the area. Stratum 4a 2 is related to a distal deposition of a glaciogenic material in relatively deep water, forming varved clay. The increasing amount of silt in the upper part of this stratum is probably explained by increasing stream velocity. Stratum 4a 1 can either be explained as a continuation of the underlying stratum or as a redeposited fluvial material formed during a late stage of the Baltic Ice Lake regression.

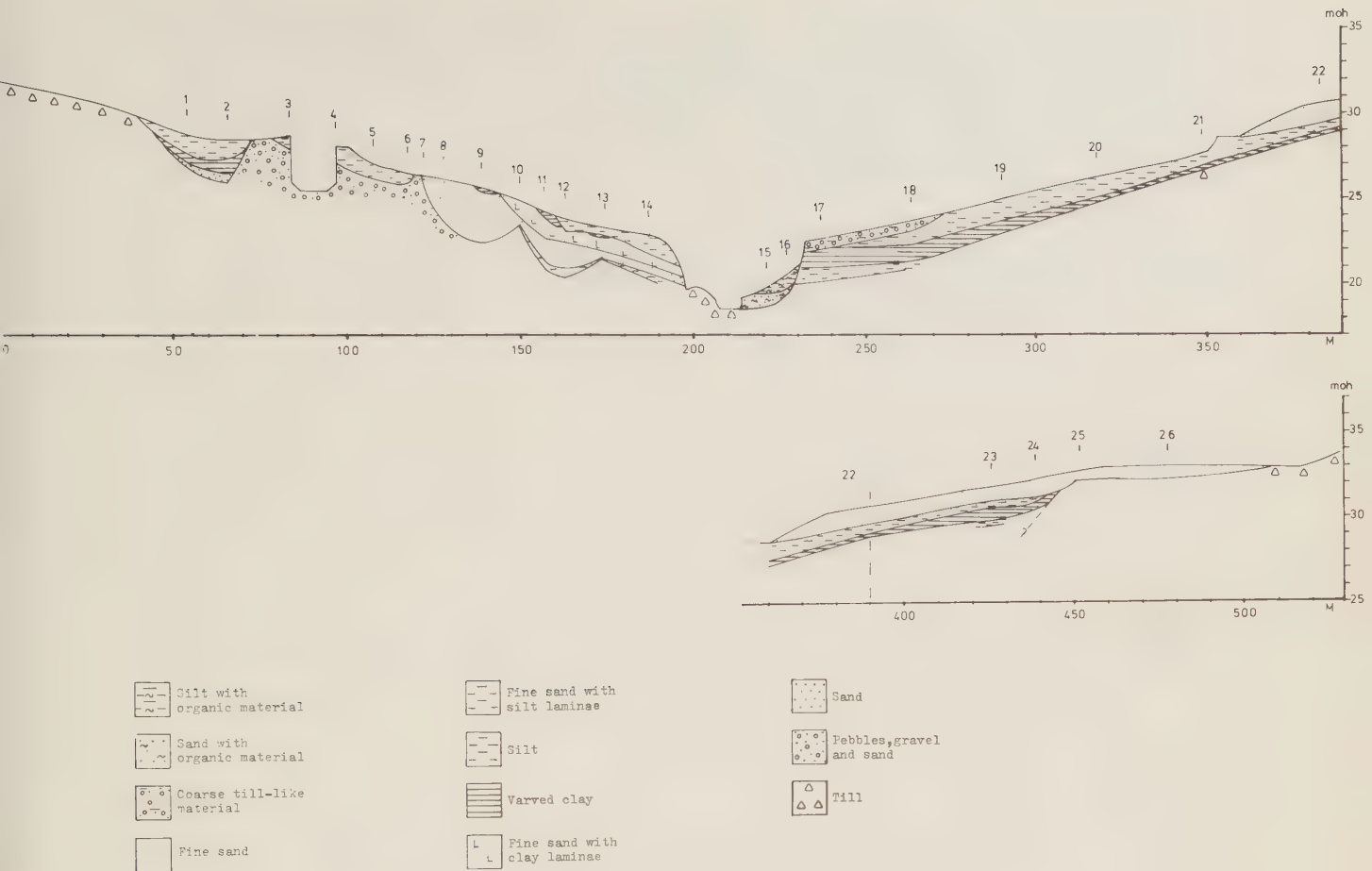


Fig. 72. A stratigraphic profile across the Åbyå river valley at Kråkerum. The valley is seen from the south. The figures refer to the bore-holes and the profiles. (After Björck and Möller 1977)

8.4.2. Kråkerum (4b)

This site (Fig. 51) is located just southwest of Kråkerum and northwest of Flä, and the area is situated between 25 and 30 m a.s.l. 24 borings and a small gravel pit have been used to produce a profile across the river valley (Fig. 72), and the stratigraphy described below is a synthesis of the points of this profile.

The sediments of the Kråkerum area have been divided into eight strata (4b 1 - 4b 8).

4b 1

This is the uppermost recorded strata from the Kråkerum area, and it consists of silt with organic material consisting partly of wood remains. It is only found at the bottom of the river valley. The thickness of this stratum does not exceed 0.5 cm.

- 4b 2 This stratum consists of unsorted minerogenic material, with relatively coarse organic material, mainly wood remains. It is only found on the edge of the eastern sediment plain. Its thickness is about 0.3 m.
- 4b 3 This stratum consists of sand and some gravel with organic material. Like stratum 4b 1 this material is only found at the bottom of the valley. The thickness of this stratum is at least 1 m.
- 4b 4 This stratum consists mainly of fine sand and is found at the border between the till and the sediment plain. The maximum thickness found is 1 m.
- 4b 5 This stratum consists of silt usually interbedded with fine sand. It is found in most of the bore-holes and does not exceed a thickness of 1 m.
- 4b 6 This stratum consists of laminated clay and silt. The silt fraction dominates the upper part of this stratum, while clay dominates the lower part, with the exception of the lowermost parts, which are often characterized by fine sand with clay laminae. The maximum thickness of this stratum is 1.8 m.
- 4b 7 This stratum consists of pebbles, gravel and sand. It is usually poorly stratified, with the exception of some gravel laminae. Sometimes the upper part of this stratum consists of sand, overlying relatively unsorted material. Where this stratum is found in a gravel pit on the western side of the valley it seems to belong to a partly buried ridge. At most this stratum has a thickness of 2.9 m. Dip and orientation analyses show that the material was transported from WNW.
- 4b 8 This stratum, which is the lowermost recorded from the Kråkerum area, consists of unsorted material, with a comparatively high content of boulders and pebbles. This material has been found at the surface in the bottom of the valley as well as in a bore-hole underlying stratum 4b 7. The thickness is at least 0.5 m.

Stratum 4 b 8 is interpreted as being till, deposited during the glaciation and/or the deglaciation of the valley. Stratum 4b 7 is interpreted as being a glacio-fluvial deposit, with at least parts of it belonging to an esker. This material was thus formed during the deglaciation. Stratum 4b 6 is related to a gradually more distal, glacial sedimentation in relatively deep water. The coarser lowermost parts of this stratum are probably the most proximal varves in a section of varved clay. This clay gets more silty upwards, which is considered to be due to increasing velocity of the transporting water. Stratum 4b 5 is either a continuation of stratum 4b 6 or was formed during a late stage of the regression of the Baltic Ice Lake by fluvial transport of these sediments from a slightly higher altitude to the altitudes where they are situated today. A combination of these two interpretations is also possible. Stratum 4b 4 is interpreted as being a deposit formed by wave-washing of till covered shores during the regression. Stratum 4b 3 is presumed to have been deposited during a high water stage of the Baltic, with accumulation of rather coarse minerogenic material, mixed with organic material, consisting partly of wood remains. This stratum will be discussed in more detail in connection with site 4c. Strata 4b 2 and 4b 1 are both interpreted as being formed by solifluction processes. Stratum 4b 2 is a mixture of coarse and fine material, while stratum 4b 1 consists of almost pure silt and is only found near to the very steep slope on the upper sediment plain. This deposit is usually in the shape of elongated lobes.

8.4.3. Hagalund (4c)

This site is located just north of Jämjö (Fig. 51), and the profile investigated (Fig. 73) extends from Fridhem to a point 200 m south of Flä. The valley is only 250 m wide, surrounded by till and bedrock, with the stream situated almost 15 m below the sediment plain. 12 borings have been carried out for the profile, and the stratigraphy of this site is a synthesis of these borings.

The sediments from the Hagalund area have been divided into six strata (4c 1 - 4c 6).

4c 1 This stream is the uppermost recorded, and it consists

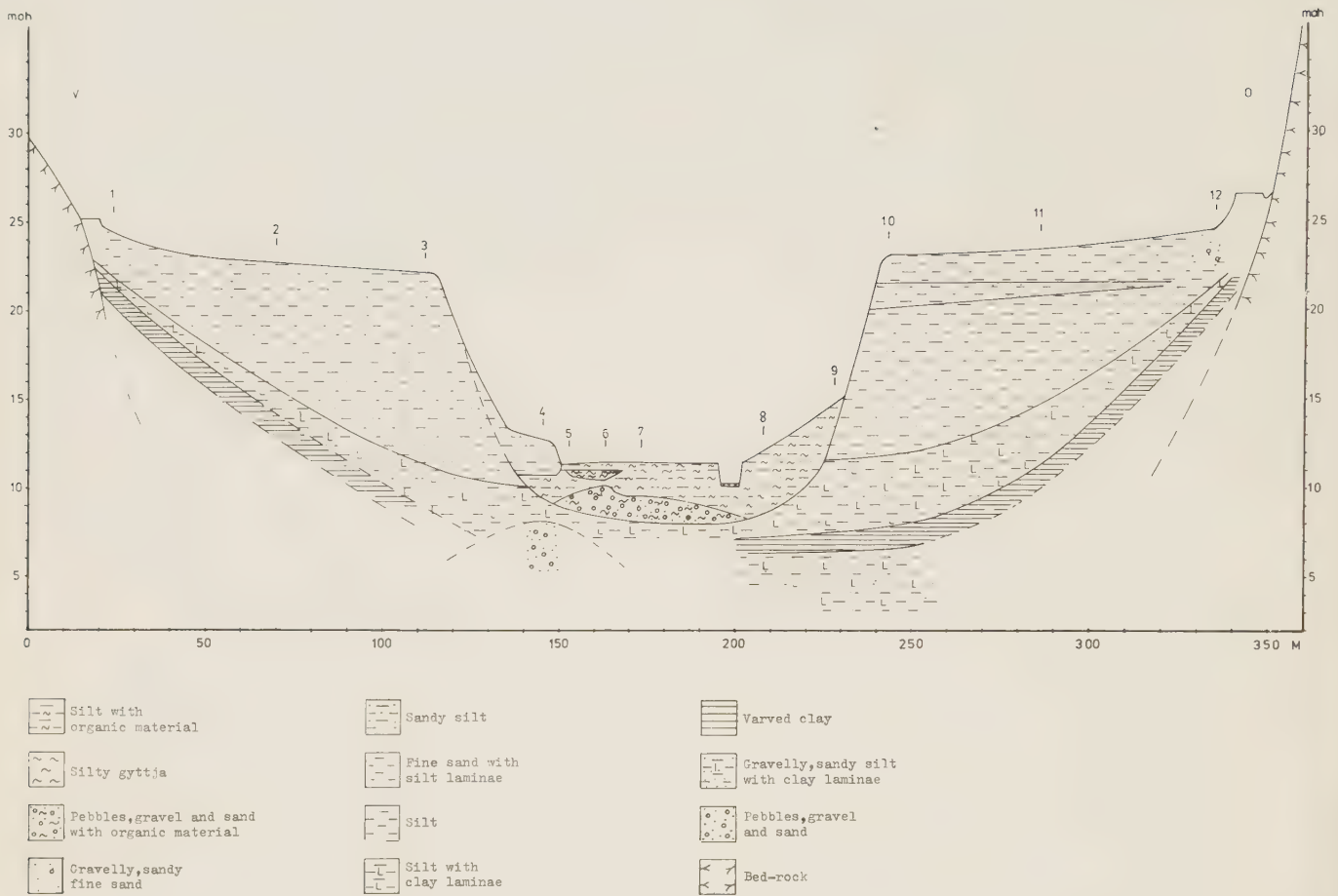


Fig. 73. A profile across the Åbyå river valley at Hagalund. The valley is seen from the south. The figures refer to the bore-holes. (After Björck and Möller 1977)

of silt with organic material. The organic material consists mainly of gyttja and wood remains. These wood remains consist of trunks and branches of Alnus. The radiocarbon age given by some of the wood remains is 1570 ± 50 years B.P. (Lu-1261). This stratum is only found in the deepest part of the valley, where the stream is situated. The thickness of this stratum is at most 3.3 m.

4c 2

This stratum consists of pebbles, gravel and sand with organic material. The organic material is dominated by wood remains consisting of branches from Salix, Tilia and Populus, and the radiocarbon age of this material

is 4890 ± 70 years B.P. (Lu-1296). Like stratum 4c 1 this stratum is only found in the deepest part of the valley. This stratum reaches a maximum thickness of 1.3 m.

- 4c 3 This stratum consists of fine sand with some gravel and silt. It is only found near to the valley slope. The thickness of this stratum does not exceed 2.8 m.

- 4c 4 This usually rather thick stratum consists of laminated fine sand and silt. The silt fraction dominates. The thickest section of this stratum is found in the middle of the valley, where 11.3 m is found.

- 4c 5 This stratum consists of laminated silt and clay. The silt fraction dominates in the upper part of the stratum, while the lower part is much more clayey, with the exception of the lowermost part, which is sometimes characterized by thin clay laminae in sandy and gravelly material. The maximum thickness of this stratum is 7.5 m.

- 4c 6 This stratum consists of gravel and sand, and is only found in one bore-hole. The morphology of this stratum is unknown, as is the thickness, but it is at least 3 m thick.

The lowermost stratum, 4c 6, is interpreted as being a glacio-fluvial deposit and is thus related to the deglaciation. Whether it belongs to an esker or not is unknown. Stratum 4c 5 is related to the sedimentation of varved clay. The coarse, lowermost, parts are interpreted as bottom varves, while the transition into the more clayey part is probably due to an increasing distance from the retreating ice. This stratum is completed by more silty laminae, which are explained by decreasing water depth and/or an increasing amount of melt water. Whether stratum 4c 4 is a direct continuation of stratum 4c 5 cannot be determined from bore-holes alone. It was either formed in rather close connection with the deglaciation as a continuation of stratum 4c 5, or it was formed during the latter part of the regression of the Baltic Ice Lake as redeposited fluvial material. Stratum 4c 3 is interpreted as being a deposit formed by wave-washing of till during the regression. This is the

reason why it is only found at the edge of the valley. Stratum 4c 2 is interpreted as fluvial material mixed with coarse organic material. The age of this material corresponds very well with the highest Littorina transgression in Blekinge (Berglund, 1971b). As the erosion base is higher during a transgression, the river valley is characterized by a more accumulative environment than during periods with a lower water level. Stratum 4c 2 is probably a remnant of this former environment. Stratum 4c 1 is interpreted as being solifluction material, perhaps mixed with some fluvial material. The radiocarbon age shows that it is considerably younger than stratum 4c 2. The wood determinations, carried out by Research Engineer T. Bartholin, as well as the radiocarbon dates show that the two uppermost strata were formed during the Holocene.

8.4.4. Lithostratigraphy of the Åbyå river valley

The deposits described from the three sites in the Åbyå river valley have been divided into seven stratigraphic units (Fig. 74). The lowermost unit, Ådalen till, represents the glaciation as well as the deglaciation of the investigation area. Till surrounding the valley, as well as till at the bottom of the sections bored, belong to this unit. The Kråkerum gravel and sand is found at all three sites. This unit is most likely related to the deglaciation, and as the investigated area is rather small, this unit is more or less synchronous within the area. It is unfortunately impossible to know what kind of formations this unit usually belongs to. The Norrgård silt and clay is a key horizon in the area, acting as an immediate reference point in the stratigraphy. Like the underlying unit, this unit is rather synchronous within this restricted area. It is a deep water sediment, influenced by a glaciogenic sedimentation environment, while the Jämjö silt is much harder to be definite about. If it is a continuation of the Norrgård silt and clay, it is not much younger than the deglaciation, while if it was deposited during the latter part of the regression of the Baltic Ice Lake it is considerably younger. The Flä fine sand was formed during the regression at different altitudes by wave-washing of the till which usually covers the bed-rock which delimits the valley. This unit is only found at the contact between the valley sediments and the

Stratigraphic units of the Åbyå river valley	Norrgård 4a	Kråkerum 4b	Hagalund 4c
Hagalund silt		4b 1 4b 2	4c 1
Fridhem gravel & sand		4b 3	4c 2
Flä fine sand		4b 4	4c 3
Jämjö silt	4a 1	4b 5	4c 4
Norrgård silt & clay	4a 2	4b 6	4c 5
Kråkerum gravel & sand	4a 3	4b 7	4c 6
Ådalen till		4b 8	

Fig. 74. Lithostratigraphic units of the Åbyå river valley related to the described strata.

surrounding bed-rock or till. The Fridhem gravel and sand with its content of organic material represents accumulation phases in the river valley, which seem to be related to high water stages in the Baltic. The Hagalund silt represents solifluction processes, which seem to be common in a river valley such as this, characterized by mainly silty sediments. These two uppermost stratigraphic units were formed during the Holocene.

8.5. Investigations of the morphology of nine esker systems in Blekinge

This investigation has been mainly carried out from studies of aerial photographs and by field observations. The purpose of this study has been to determine at what altitude and in which geographic position the transition from a rounded esker type to a sharp-edged type occurs in Blekinge. This morphological change of the esker type has earlier been interpreted by Ringberg (1971) as being a result of different rate of exposure during the regression of the Baltic Ice Lake and also as a result of the level below the highest shoreline. Due to the difference in exposure, wave-washing of the eskers has varied. When the esker has been well exposed the waves have smoothed out the originally sharp morphology. The aim of this study is to find out whether there is a relationship between the rate of exposure and the change of the esker morphology, or if this change is related to a regional altitude. The esker systems are described from the west to the east (Fig. 51).

8.5.1. The Mörrum esker system (A)

The investigations have been carried out in the southern part of the Mörrumså river valley, between Åkeholm and Elleholm. South of Mörrum the eskers are rounded, while the eskers north of Mörrum, usually buried beneath silt, are sharp. The rounded esker type is found up to about 30 m a.s.l., while the sharp-edged esker type is found down to about 40 m a.s.l. (Lagerlund and Björck, 1979). The valley does not narrow north of Mörrum, and the rate of exposure up to 4 km north of Mörrum should have been the same as south of it.

8.5.2. The Mieå esker system (B)

The area between Lake Långasjön and Karlshamn has been carefully investigated with respect to esker deposits. On the western shore of the southern part of Lake Långasjön lies an esker with steep slopes and with the upper surface situated between 55 and 60 m a.s.l. South and southwest of Lake Långasjön coarse material with a relatively horizontal extension is found. This material is usually found resting on the bed-rock, which borders the valley to the west. It is not regarded as an esker deposit, but is

probably some kind of kame formation. There are no signs of eskers between the southern part of Lake Långasjön and Karlshamn, which probably means that they are buried beneath fine-grained deposits. The sharp esker type is found from 55 m a.s.l. all the way up the valley.

8.5.3. The Hällaryd esker system (C)

The investigations have been concentrated on the area between Hällaryd and Lake Södra Öllesjön. South of and at least 1 km north of Hällaryd the esker is well rounded. At Bostället the esker is still rounded and the upper surface lies between 25 and 30 m a.s.l. But between Bostället and Lycke the esker changes shape. Just northwest of Lake Svartasjön the upper surface of the esker, which is relatively sharp, is situated at about 35 m a.s.l., with the surrounding ground surface lying at about 30 m a.s.l. The valley is narrow at Bostället, and if anything, becomes slightly wider northwards, where the transition occurs between the two esker types. There seems to be no evidence to suggest that this change is related to differences in the rate of exposure.

8.5.4. The Bräkne esker system (D)

The investigations have been carried out in the southern part of the Bräkneå river valley, north and south of Bräkne-Hoby. It is very clear that the esker changes shape at Svenstorp, just north of Bräkne-Hoby. NNW of Svenstorp the esker is well-defined by very steep slopes, while from Svenstorp southwards it is relatively well rounded. The upper surface of the esker just NNW of Svenstorp lies between 30 and 35 m a.s.l., while the surrounding flat land is situated between 25 and 30 m a.s.l. The transition between these two esker types occurs in the middle of the almost 2 km wide valley. The exposure of the esker should have been the same everywhere in this wide valley during the regression.

8.5.5. The Bredåkra esker system (E)

This esker, which according to Ringberg (1971) should be regarded as a contributory esker to the Bredåkra delta, has been investigated north and south of Kallinge. The esker is rounded at Hyndekulla,

1.5 km south of Kallinge. The upper surface lies about 35 m a.s.l., while the surroundings are situated between 25 and 30 m a.s.l. At Hyndekulla the valley is only two hundred metres wide, while the valley appears to be much wider at Kalleberga, just north of Kallinge. However, the esker is very sharp at Kalleberga (Fig. 68) and the upper surface is situated between 50 and 55 m a.s.l. This means that the transition between these two esker types lies somewhere between Hyndekulla and Kalleberga, and is thus situated between 35 and 50 m a.s.l. The exposure to wave erosion should have been greater at Kalleberga than at Hyndekulla.

8.5.6. The Mölleryd esker system (F)

This esker system has been carefully investigated between Listerby and Mölleryd. Between Listerby and Stubbetorpet the esker is well rounded with a highest altitude of 30 to 35 m a.s.l. 300 m north of Stubbetorpet the esker becomes much sharper and narrower. The upper surface lies between 35 and 40 m a.s.l. From this point the esker is very narrow and is well-defined by very steep slopes. The valley becomes narrower south of Stubbetorpet, which could point to the sharp esker being a product of reduced rates of exposure. But the valley north of Stubbetorpet is very flat and still comparatively wide. So it seems rather unlikely that this striking change in the form of the esker is a function of a slightly narrower valley.

8.5.7. The Johannishus esker system (G)

This esker has been investigated in detail between Listerby and Johannishus manor. The transition from a well rounded to a much less rounded esker occurs at the bell-tower of Hjortsberga. Just south of the bell-tower the upper surface reaches about 32 m a.s.l. At the school, between the bell-tower and the manor, the esker, which is relatively sharp, reaches more than 35 m a.s.l. The surrounding fields lie between 25 and 30 m a.s.l. The width of the valley is about the same all the way between Listerby and Johannishus manor, which does not suggest that the rate of exposure varied considerably.

The esker systems	Highest rounded top surface	Lowest sharp top surface
Mörnum	30 m.a.s.l.	40 m.a.s.l.
Mie	?	55 m.a.s.l.
Hällaryd	30 m.a.s.l.	35 m.a.s.l.
Bräkne	30-35 m.a.s.l.	30-35 m.a.s.l.
Bredåkra	30-35 m.a.s.l.	50 m.a.s.l.
Mölleryd	30-35 m.a.s.l.	35-40 m.a.s.l.
Johannishus	32 m.a.s.l.	35 m.a.s.l.
Tving	35 m.a.s.l.	35 m.a.s.l.
Augerum	35 m.a.s.l.	40-45 m.a.s.l.

Fig. 75. The relation between esker morphology and altitude for nine esker systems in Blekinge.

8.5.8. The Tving esker system (H)

This esker has been investigated between Almö and Larum. Just west of Lake Emmahultsjön the shape of the esker changes from a rounded, undistinct ridge to a sharp, distinct ridge. This transition occurs when the upper surface of the esker is situated about 35 m a.s.l. The esker lies in a scarcely distinguishable depression, which can hardly be regarded as a valley. No signs of differences in the rate of exposure of the esker can be found.

8.5.9. The Augerum esker system (I)

The investigations concerning this esker have been carried out in the Lyckebyå river valley, between Augerum and Biskopsberg. From Augerum and 2.5 km northeastwards the esker is hardly distinguishable at all, with the upper very smooth surface situated between

30 and 35 m a.s.l. From there (where the upper surface lies about 40 m a.s.l.) and further up in the valley the esker is sharp. At Biskopsberg the esker is well-defined by very steep slopes, with the upper surface situated between 50 and 55 m a.s.l. This means that the transition between the two esker types occurs between 35 and 40 m a.s.l. According to Ringberg (1971) the presence of this sharply shaped esker is due to the fact that the esker lies in a protecting narrow fissure valley. According to him it was possibly also protected by dead-ice during the regression, which made wave erosion of the esker ridge almost impossible. The valley, however, is about the same width all the way from Augerum to Biskopsberg, which makes an explanation of the transition from a diffuse esker form to a sharp-edged esker type in terms of differences in the rate of exposure unlikely.

8.5.10. The relation between the esker morphology and the height above sea level for nine esker systems in Blekinge

It is quite obvious from Fig. 75 that the change from a rounded to a sharp-edged esker type in Blekinge seems to be related to height above sea level. This change is very rarely related to differences in the rate of exposure of the esker ridge during the regression of the Baltic Ice Lake. The altitude of 30 to 40 m a.s.l. seems to be critical in the regional change of esker morphology in Blekinge.

9. THE REGIONAL LITHOSTRATIGRAPHY RELATED TO ABSOLUTE CHRONOLOGY AND SHORE LINE DISPLACEMENT

In Fig. 76 the strata described are correlated with the regional lithostratigraphy established and described in detail by Lagerlund and Björck (1979), and in Fig. 77 the chronology and shore displacement curve is related to the regional formations. On the basis of the stratigraphy from Kroksjön (site 5) it is obvious that the Sörby Varved Clay Member, as it represents all measured varves in Blekinge, the Heaby gravel and the Gö till are older than the highest shore line. This means that the boundary between the Listerby Lower and the Listerby Upper Formation has an approximate age of 12,000 radiocarbon years, as the Hakarp clay can be correlated with layer 2 in Kroksjön. The Listerby Upper Formation was thus formed during the regression of the Baltic Ice Lake. This regression is well illustrated by the gradually coarser material of the Listerby Upper Formation. The Häljarum gravel was deposited by wave-washing and the Hinseberget silty sand by fluvial redeposition during the very last phase of the regression during the Younger Dryas Chronozone.

As the boundary between the Listerby Formation and the Ronneby Formation is related to the last rapid regression of the Baltic Ice Lake this boundary is dated to about 10,250 radiocarbon years B.P.

At lower altitudes (30-55 m a.s.l.) the Svängsta Formation consists mainly of till and sharp-edged eskers, usually buried beneath the Mörrum Formation (Fig. 76), while it is in places overlain by the Ronneby Formation at higher altitudes. At these altitudes the Svängsta Formation consists of different types of till, eskers, kame terraces, kame deltas and kames. All deposits described in the river valleys, with the exception of Baltic Ice Lake beach deposits (Nydale beds), situated higher than 55 m a.s.l. belong to this formation. This formation represents the last phase of the deglaciation within the investigation area. The distal deposit of this formation is varved clay. This means that the upper boundary of the Sörby Varved Clay Member is most likely not older than the major part of the Svängsta Formation within the investigation area. The Svängsta Formation was thus mainly formed before 12,000 B.P., which means that it was formed during the postulated transgression.

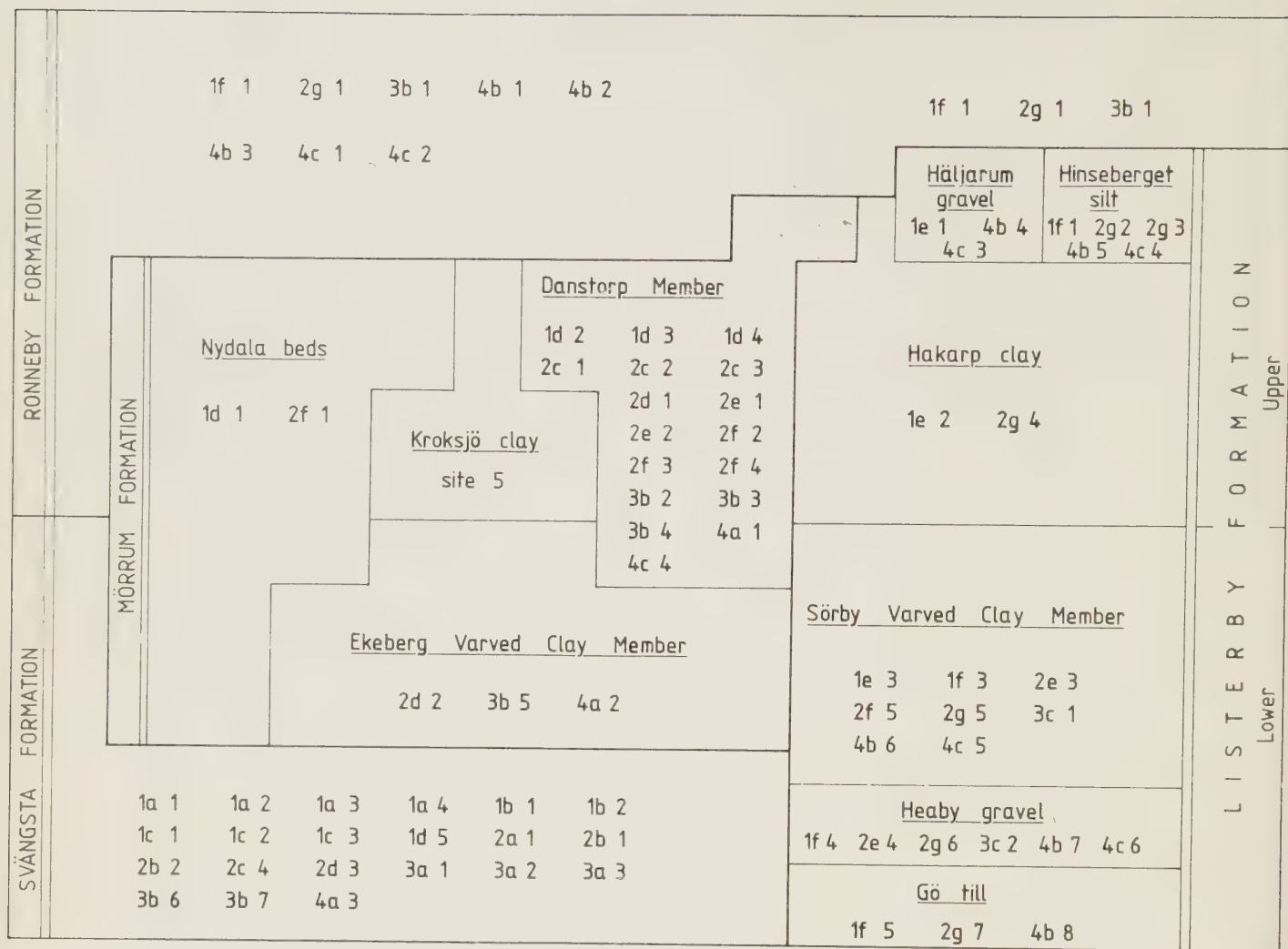


Fig. 76. The described strata related to the regional lithostratigraphic facies diagram (Lagerlund and Björck 1979). The vertical line between the Mörrum Formation and the Listerby Formation represents an altitude of about 30 m.

The complex Mörrum Formation is found between about 30 and 65 m a.s.l. The Ekeberg Varved Clay Member was formed mainly before the highest shore line was developed, as it is correlated with parts of the Sörby Varved Clay Member. The Kroksjö clay has not yet been found between the Ekeberg Varved Clay Member and the Danstorp Member, but should exist in the southern part of the areas where the Mörrum Formation is found (Lagerlund and Björck 1979). This is because the Danstorp Member is believed to have been formed at the same time as at least the upper part of the Sörby Varved Clay Member, and the whole of the Hakarp clay. The Danstorp Member is considered to be a complex of fluvial deposited formations situated between 30 and 55 m a.s.l. The very sudden change in

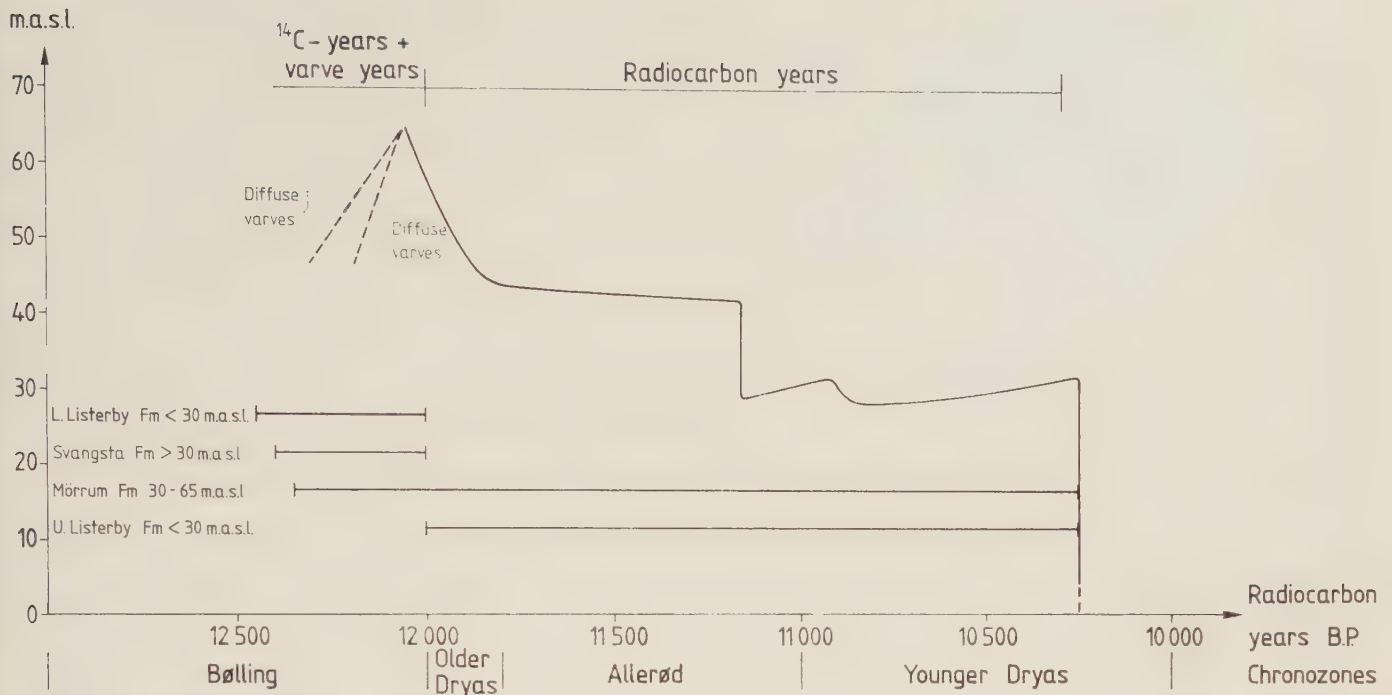


Fig. 77. The lithostratigraphic formations related to the chronology and the shore line displacement curve.

sedimentation rate between the Ekeberg Varved Clay Member and the lower part of the Danstorp Member is very distinct in the Mörrumså river valley (Lagerlund and Björck 1979) as well as in the other valleys. The silt in the lower part of the Danstorp Member is correlated with the bottomset beds at Tararp (site 1d), Muggeboda (site 2c) and Bredåkra (site 3b), and also with some other strata (Fig. 76). As was pointed out in the description of the Bredåkra delta, the diffuse varve type is correlated with the bottomset bed and possibly also to parts of the foreset bed. This means that the silt was at least partly deposited prior to the development of the highest shore line as the diffuse varve type at Kroksjön predates the boundary between the Bölling Chronozone and the Older Dryas Chronozone by about 150 varve years. Whether the deltas at Danstorp (Lagerlund and Björck 1979), Tararp, Muggeboda and Bredåkra were completely built up before 12,000 B.P. or not, is not possible to determine with certainty. However, as no clay has been found overlying the topset beds of these deltas they are interpreted for the moment as being completely shaped during the very early phase of the regression, when the Baltic Ice Lake was situated around 55 m a.s.l., although the major part of the sediments are interpreted as being deposited during the period with diffuse varves and thus

during the suggested transgression up to the highest shore line. As the regression of the Baltic Ice Lake continued, more or less completely built up deltas were formed at lower and lower altitudes. Much of this delta material is believed to originate by erosion from the higher situated deltas. The very distinct stratum 2e 1 at Lindefors in the Bräkneå river valley could be related to the rapid lowering of the Baltic Ice Lake at the end of the Alleröd Chronozone, which must have lowered the erosion base considerably, with a suddenly increased erosion at higher altitudes and accumulation at lower altitudes as a consequence. This sudden lowering of the erosion base could thus be the cause of the change of drainage pattern described in the Bräkneå river valley with erosion of coarse glacio-fluvial as a consequence. A similar change of drainage pattern in the Ronnebyå river valley is described by Hebrand (1978). The Younger Dryas Chronozone represents an important period during the regression, as the water level of the Baltic Ice Lake was rather constant during that time. This caused erosion of the Danstorp Member at higher altitudes with accumulation of new deltas at about 30 m a.s.l., e.g. the Mörrum delta (Lagerlund and Björck 1979), still belonging to the Danstorp Member of the Mörrum Formation, and more distal deposits below 30 m a.s.l. with deposition of the Hinseberget silty sand belonging to the Upper Listerby Formation. The Nydala beds were deposited during the same period as the Mörrum Formation as a result of wave-washing mainly during the regression and do thus represent the beach deposits in the Baltic Ice Lake between 30 and 65 m a.s.l. The end of this formation and the beginning of the Ronneby Formation is marked by the lowering of the Baltic Ice Lake causing isolation of lakes progressively at lower altitudes and with the youngest isolation dated to about 10,250 radiocarbon years B.P., which is represented by e.g. the final isolation of Halsjön (30 m a.s.l.).

It is obvious from the discussion above that the lithostratigraphy in Blekinge is very closely associated with the regression of the Baltic Ice Lake, which is fortunately rather accurately dated between 12,000 and 10,250 radiocarbon years B.P. However, the time period before the highest shore line was developed is much more complex, as the formations deposited above 30 m a.s.l. during this time are mainly characterized by the deglaciation. It is very hard to find any evidence for the postulated transgression in these

deposits. Strata 2c 4 and 2d 3 in Bräkneå river valley could be explained as being deposited previous to a transgression, and kame terraces situated between 55 and 65 m a.s.l. could also indicate a lower water level than the highest shore line, if they were formed some time during the deposition of varved clay further southwards. Hebrand (1978) described what he called wave-washed material at the Bredåkra delta overlying a sharp-edged esker itself overlain by a complete delta sequence. This type of stratigraphy is, however, found at other places in the area, but is difficult to interpret. The regional change of esker type at about 35 m a.s.l. (the till or bed-rock surface is usually situated about 20-25 m a.s.l.) could indicate a lower water level than the highest shore line during the deglaciation. This would, however, demand a thin ice (less than 30-40 m thick) as the deglaciation took place by calving up to this altitude. This is discussed in more detail in Chapter 11.

The approximate age of each Pleistocene Formation is as follows (dates older than 12,000 are calculated as radiocarbon years + varve years), which is also shown in Fig. 77.

The Listerby Formation	12,450 - 12,000
The Upper Listerby Formation	12,000 - 10,250
The Svängsta Formation	12,400 - 12,000
The Mörrum Formation	12,350 - 10,250

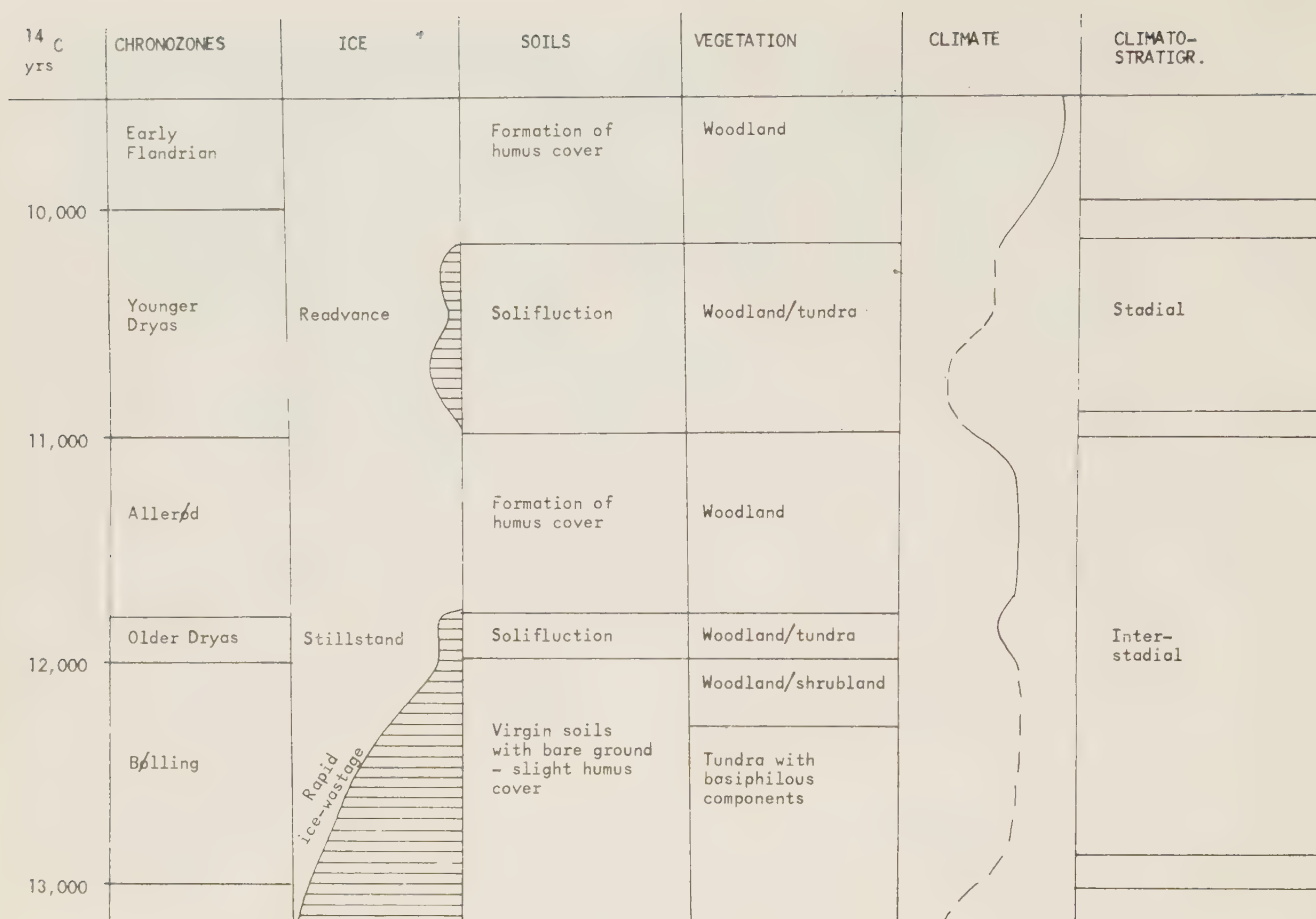


Fig. 78. A synthesis of the environmental changes in South Sweden related to the chronostratigraphy. The climate curve is an approximate reconstruction of summer temperature changes. From Berglund (1979).

10. THE RELATION BETWEEN THE REGIONAL BIO- AND LITHOSTRATIGRAPHY

Fig. 78 is a synthesis of the environmental changes in South Sweden related to the chronostratigraphy (Berglund 1979). The regional pollen assemblage zones in this work, which reflect these changes, have been related to the radiocarbon chronology as well as to the local varve chronology, and the regional lithostratigraphy has been related to the radiocarbon dated shore line displacement as well as to the local varve chronology. As new concentration methods for pollen in clays have been developed, it has been possible to analyse the pollen content of glaciogenic sediments (mainly varved clay). This has been shown to be very valuable as these sediments have been assigned to the Bölling

Chronozone on the basis of the pollen spectra. These results clearly show that the lacustrine sediments deposited during the deglaciation phase in Blekinge record a glacially influenced environment as well as an environment characterized by specific plant communities. The climatic deterioration during the Older Dryas Chronozone (zone 2), recorded in the pollen diagrams by increasing values of cold tolerant herbs, is related to the first non-glaciogenic deposits (non-varved clay) in Blekinge after the last glaciation. This means that the sediments were possibly not glacially influenced in Blekinge during this short stadial period. It is obvious that the pollen spectra from the Alleröd Chronozone (zones 3 and 4) show a climatic amelioration. This is also shown by the increasing values of loss on ignition in the lake sediments. However, these increasing values are also a function of the regression, as more and more land emerged out of the Baltic Ice Lake and was colonized by plants and animals. During this time the Listerby Upper Formation and the Mörrum Formation were deposited. The river valleys were characterized mainly by fluvial erosion and accumulation with lacustrine sedimentation outside the river mouths. Large parts of Blekinge today were still covered by water. The regional assemblage zones 5 and 6 from the Younger Dryas Chronozone are characterized by pollen indicating a drastic climatic deterioration. The river valleys were characterized by accumulation around 30 m a.s.l. during this time, as the shore of the Baltic Ice Lake was situated at about this altitude during the greater part of the Younger Dryas Chronozone. Probably most of the ice-wedges found in Blekinge originate from this last stadial. However, the ice-wedges situated highest (more than 60 m a.s.l.) could have been initially shaped during the Older Dryas Chronozone. The upper boundaries of the Pleistocene lithostratigraphic formations coincide very well with zone 7, where pollen spectra clearly suggest a climatic amelioration. This means that the very upper part of the Younger Dryas Chronozone corresponds with important changes of a biostratigraphic as well as a lithostratigraphic nature. The boundary between the Pleistocene and the Holocene is just slightly younger than these very significant and important boundaries in Blekinge. It is obvious from the discussion above that climatic changes are best recorded in the lake sediments, while sedimentary changes, usually related to the deglaciation or the shore line displacement, are best recorded in the river valleys.

11. THE DEGLACIATION OF BLEKINGE

11.1. Dating of the deglaciation

The age of the deglaciation in most parts of Sweden has previously been dated by the varve chronology, which has also been done in Blekinge. The latest varve chronological work in this area linked to the Swedish time scale was carried out by Ringberg (1971), who dated the deglaciation of the coast of Blekinge to 10,200 B.C. This date is based on the revised Swedish time scale following Nilsson (1968). However, Ringberg (1979) published a floating chronology for NE Scania and Blekinge because of correlation problems attached to the varve chronology in southern Sweden (Fig. 8). Berglund (1966) radiocarbon dated lake sediments in Blekinge with the oldest age being from Lösensjön ($11,740 \pm 170$ conv. ^{14}C years B.P.). Principally on the basis of high radiocarbon dates from Småland and southwestern Sweden, Berglund (1976) came to the conclusion that Blekinge was deglaciated during the early part of the Bölling Chronozone as a result of down-wasting of thin ice, especially characterizing areas above the highest shore line. This could also explain the high recession rate, which the radiocarbon dates suggest. Berglund (1979) (Fig. 79) suggested the possibility that Blekinge was partially deglaciated in the time interval 12,800 - 12,600 ^{14}C years B.P., which also is the date of the Gothenburg Moraine on the Swedish west coast. Ringberg (1979) showed that the varve series in Blekinge contained about 400 varves. The varve diagram from Kroksjön (site 5 in this work) shows that up to about 450 varves can be found in Blekinge. As has been pointed out before, the evidence points to the fact that the varved clay in Blekinge was deposited during the Bölling Chronozone. Unfortunately the boundary between the Bölling and Older Dryas Chronozone has not been radiocarbon dated in Blekinge, due to the very low amount of organic material characterizing the sediments belonging to regional assemblage zones 1 and 2. However, the chronostratigraphic subdivision proposed by Mangerud et al. (1974) is based on the old climato-biostratigraphic zones recorded from Denmark, southern Sweden and southern Norway. This means that the boundary between the Bölling Chronozone and the Older Dryas Chronozone corresponds with the boundary between pollen zones Ib and Ic (Iversen 1954) and pollen zones BÖ and DR2 (Nilsson 1961). This climato- and pollenstratigraphical boundary is correlated with the boundary

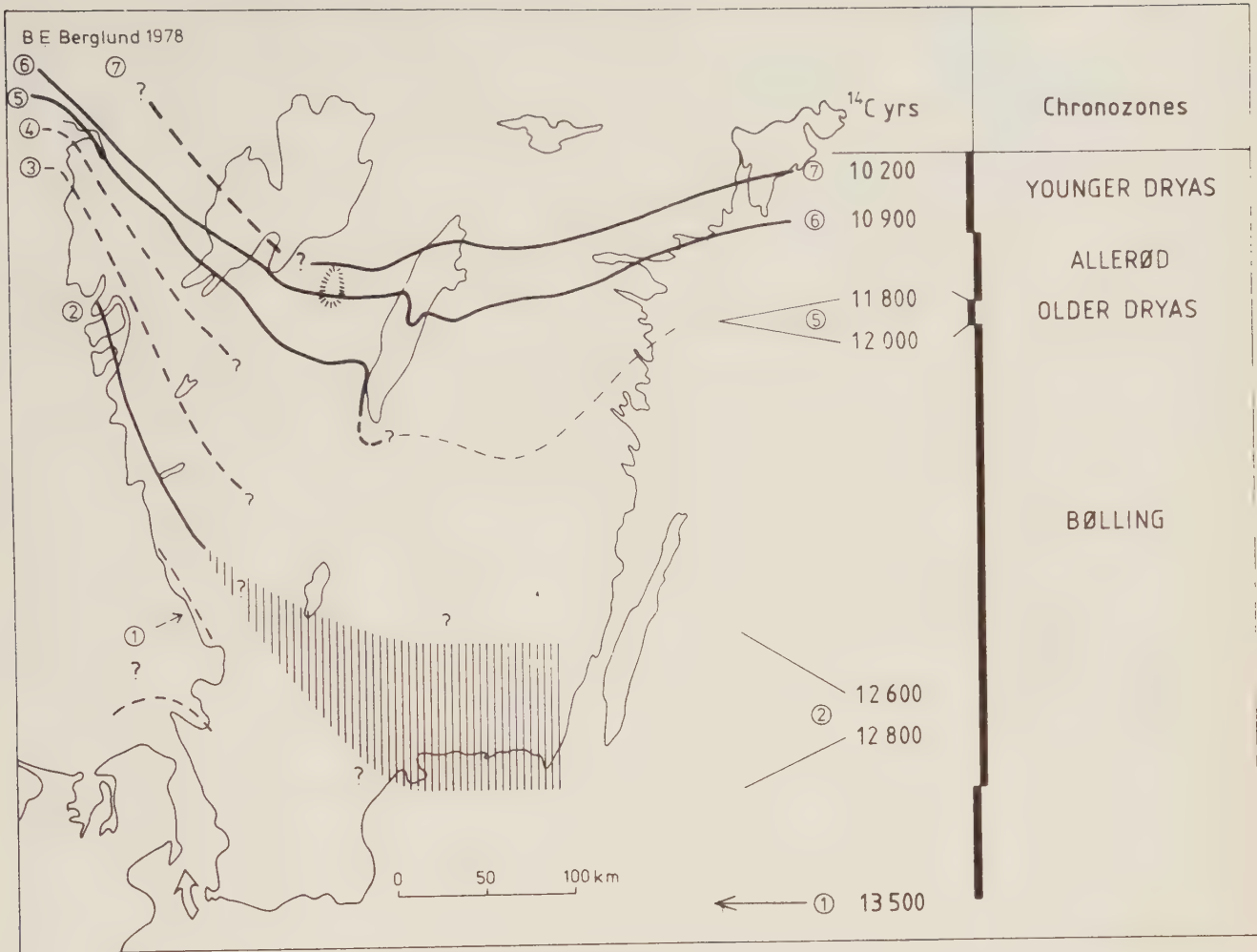


Fig. 79. Map showing the revised deglaciation chronology for SW Sweden, according to Berglund (1979). The dated ice-marginal zones are correlated with the chronostratigraphic system proposed by Mangerud et al. (1974).

between zones 1 and 2 in this work, which thus means that the age of this boundary is 12,000 radiocarbon years B.P. An age of 12,000 years for the upper boundary of the varved clay in Kroksjön would mean that today's coast of Blekinge became ice-free 12,000 radiocarbon years + 450 varve years B.P. However, as the radiocarbon chronology is not calibrated to calendar years during this time period it is impossible to give an exact date in radiocarbon years for the time of the deglaciation. Presuming the error within these 450 varve years compared with radiocarbon years is less than ± 150 radiocarbon years it means that the deglaciation of Blekinge began some time between 12,600 and 12,300 conventional radiocarbon years before present. This date coincides well with Mörner's (1975 b) date of the Bredåkra delta (12,400 - 12,350 B.P.), which he correlates with the Gothenburg Magnetic "Flip" of the Fjärås

stadial'. However, Ringberg (1976) has pointed out that this correlation is based on unreliable calculations, and Berglund's (1976) compilation of radiocarbon dates shows that the 'Fjärås stadial' (= formation of the Gothenburg Moraine) is dated to 12,800 - 12,600 radiocarbon years. Mörner (1975 b) also correlated the diffuse varve type to a climatic deterioration (the 'Fjärås stadial'). However, this is contradicted by the fact that according to this work the whole varve series from Blekinge was deposited before the Older Dryas Chronozone, and that the diffuse varves were deposited about 200 varve years before this short stadial period. As varved clay was not deposited after the Bölling Chronozone, this shows that Blekinge was free from ice, for the most part, at 12,000 B.P., and probably even earlier. Ringberg (1971 and 1979) showed that the southernmost 10 km of Blekinge became ice-free during the first 100 years of deglaciation. The correlation between the diffuse varve type and delta sedimentation slightly below the highest shore line shows that areas up to this altitude were probably free from ice when the first diffuse varves were deposited. This would mean that the major part of Blekinge could have been ice-free 12,000 radiocarbon years + 250 varve years B.P. Rapid deglaciation is also suggested by the presence of about 300 varves in Kroksjön, which is situated relatively far from the coast at a relatively high altitude, characterized by ice-disintegration features (see next section).

11.2. The deglaciation pattern

The deglaciation model described below is a synthesis of the lithostratigraphical as well as chronological results obtained from this investigation and represents, in some cases, an improvement of the briefly outlined deglaciation model described by Lagerlund and Björck (1979), which is mainly based on lithostratigraphical data. As this investigation has mainly been dealing with deposits below the highest shore line, the deglaciation pattern will principally be described for areas situated at altitudes lower than about 80 m.

In Fig. 80 a generalized picture is shown to illustrate the relations between the different formations, and in Fig. 81 the deposits are related to processes and altitudes. The reason for dividing the glacial and glacio-fluvial deposits into two different formations,

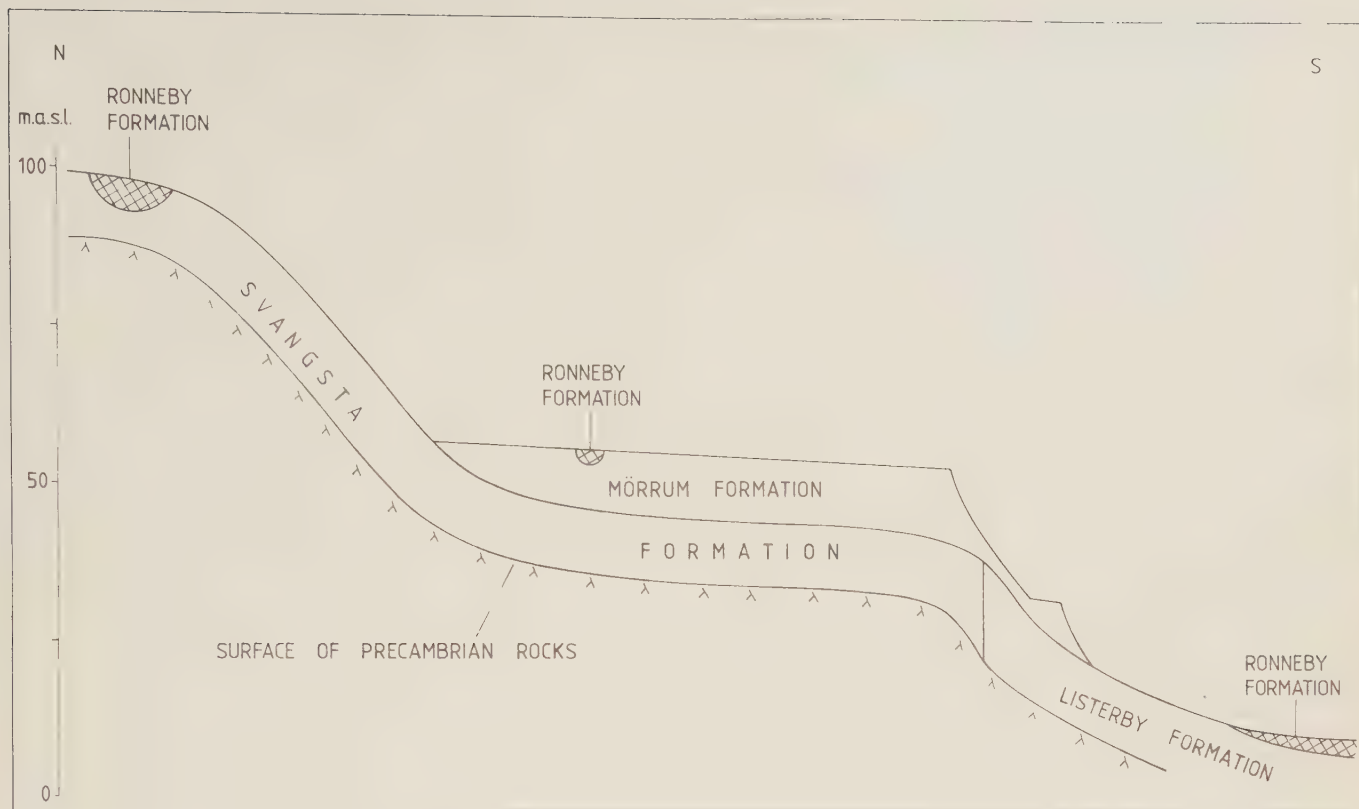


Fig. 80. A generalized picture illustrating the relations between the four lithostratigraphic formations. From Lagerlund and Björck (1979).

the Listerby Formation and the Svängsta Formation, is very important. Ringberg (1971) described the southern part of Blekinge as having been deglaciated by a frontal deglaciation characterized by deposition of varved clay progressively northwards. It is clear from the description of the esker system as well as from the lithostratigraphic subdivision that the morphology as well as the stratigraphy change character between 30 and 40 m a.s.l. This important change is believed to reflect two types of deglaciation environments. The Heaby gravel and the Sörby Varved Clay Member represents deglaciation in a glacio-lacustrine environment, which was the condition for these two stratigraphic units to be deposited. The Heaby gravel deposits consist of rounded eskers formed at or inside the calving ice-margin and which were covered with a proximal bottom varve, in relation to the exit of the subglacial stream tunnels, the first time the esker was situated some distance outside the margin, which means that these eskers often are covered by a mantle of sandy or silty material. This boundary between a glacio-lacustrine environment and an environment characterized by the presence of an ice-margin is stratigraphically represented by the boundary between the

Altitude	Environment and processes	Deposits
>55ma.sl.	Glacio-fluvial sedimentation Ablation Stagnant ice	Kame terraces Kame deltas Sharp-edged eskers Till
30-55 m.a.s.l.	Glacio-lacustrine sedimentation Calving Glacio-fluvial sedimentation Ablation Stagnant ice	Delta sediments Varved clay with thin bottomvarves Sharp-edged eskers Till
<30ma.sl.	Glacio-lacustrine sedimentation Calving Glacio-fluvial sedimentation Frontal deglaciation	Varved clay Rounded eskers

Fig. 81. Pleistocene deposits found in Blekinge related to environment, processes and altitude.

Sörby Varved Clay Member and the Heaby gravel. According to Ringberg's varve chronology (1971 and 1979) and from the studies of the esker morphology this type of deglaciation could have been in progress for 100 varve years at the maximum in most parts of Blekinge. However, in some of the wider and deeper valleys this could have continued for another 40-50 years, while the surrounding areas were at the same time still covered by ice and characterized by another type of deglaciation, represented by the Svängsta Formation. This means that the equicesses should follow the topography rather well, which possibly shows that the water depth in the Baltic Ice Lake together with the ice thickness determined the calving and thus also the equicesses. The consequence of this is that it is not possible to determine the equicesses between the

valleys when investigated localities of varved clay are missing in these areas. This also means that the valleys were calving bays. Ringberg (1971) showed the existence of at least one such bay east of Ronneby. The Svängsta Formation is characterized by different types of till, sharp-edged eskers, kame deltas, kame terraces and kames. According to the morphology in the valleys the change between these two types of deglaciation took place very suddenly. The main reason for this change is believed to be due to the suddenly increasing altitude of the bed-rock surface in the river valleys about 10 km from the coast. This regional feature is clearly shown in Figs. 51 and 56 as well as in Fig. 80. The ice-recession previously characterized by calving changed to an environment characterized by ablation processes due to a markedly decreasing water depth. In this wasting ice the drainage probably took place in fissures and/or tunnels, in which the eskers were formed. These eskers are often characterized by coarse material, sometimes poorly sorted, and by ice-contact slopes. This shows that the deposits were originally surrounded by ice and formed by high flow. Between 30 and 55 m a.s.l. the river valleys are characterized by the Svängsta Formation, usually consisting of these sharp-edged eskers and overlain by the Mörrum Formation. This means that the eskers are usually buried beneath fine-grained deposits, which in some places consist of varved clay in the bottommost part. It is obvious that the boundary between the Svängsta Formation and the Ekeberg Varved Clay Member represents another important environmental change. The most characteristic property of this change is the sudden presence of varved clay on top of the very coarse esker material without any transition in grain-size, which thus means that these eskers are covered by distal bottomvarves, distal in relation to the source of the material. The presence of this type of varve indicates that the ice suddenly disappeared due to increasing water depth and/or decreasing ice thickness. This sudden disappearance, interpreted as being caused by calving of former bottom-fixed ice caused deposition of varved clay without any proximal bottom varves. At the type site the Ekeberg Varved Clay Member in the Mörrumså river valley consists of 45 varves, overlying esker material, which suddenly changes upwards to the silt of the Danstorp Member. As this silt is correlated with the diffuse varve type and as the previous 45 varves can be linked with the varves predating the diffuse varve type in Blekinge (Lagerlund and Björck 1979) it means that the ice disappeared at about the time

of deposition of the local varve year + 70 up to about 50 m a.s.l. in the Mörrumså river valley (Ringberg 1979). As the equicess for this area is + 10 (Ringberg 1979) it would mean that the ice stayed stagnant in this part of the valley during a period of about 60 years. A similar state seems to be valid for the western valley in the Bräkneå river valley system (site 2c and 2d), while the eastern valley seems to have been deglaciated directly by calving. In the Hällaryd river valley (not described in this work), situated between the Mieå river valley and the Bräkneå river valley, the deglaciation up to about 50 m a.s.l. seems to have taken place in the same way as in the Mörrumså river valley. If the uppermost varves at Tararp (site 1d 164 varves altogether) in the Mieå river valley correspond to the uppermost diffuse varves, it means that 30-40 varves are missing as the equicess for this area is about - 10 and the diffuse varve type ends at about + 190. However, as the bottom was probably not reached in the bore-hole at Tararp, it is only known with certainty that the Mieå river valley was ice-free at least at the local varve year + 20 up to 55 m a.s.l. The area where the southern part of the Bredåkra delta is situated was most likely free from ice at the local varve year - 20 (Ringberg 1979). As the lowermost part of stratum 4b 6 in the Åbyå river valley is interpreted as a proximal bottom varve it means that this valley was characterized by frontal deglaciation through calving up to at least site 4b. This fits very well as the major part of this valley is situated below 30 m a.s.l. However, it is obvious that large parts of the area which are now covered by the Mörrum Formation were originally covered by wasting ice which suddenly left the area at about the same time. As the ice left these areas relatively quickly it is probable that this was not a function of ablation but rather of the water depth. If the disappearance of the ice was caused by increasing water depth, and the bottom of the ice was situated at about 30 m a.s.l., this would mean that the water level must have been situated at least 40-50 m a.s.l. at the calving, as the eskers are usually 5-10 m high. This type of deglaciation could thus be explained by a transgression and would also give a third possibility for dating the transgression. Dating the transgression in this way would mean that the thinner the ice, the greater was the transgression gradient. In any case, if a transgression took place up to the highest shore line it means that the ice could not have been much thicker than 30 m when it left the

areas beneath the Mörrum Formation. It should also be noted that the water level could have been situated at the highest shore line all the time before the regression of the Baltic Ice Lake started. The calving of the ice surrounding the eskers would then have exclusively represented wasting of the ice. Ringberg (1971) thought that the last ice movement was weak and that the glacial striae from this movement (N5 - N10°W) were followed by a relatively synchronous transition from active ice to dead-ice over large parts of Blekinge. The idea that the deglaciation was already characterized by the loss of contact with accumulation area during an early phase is supported by the fact that the eskers follow, without exception, the direction of the river valleys. This deglaciation type is further supported by the total absence of terminal moraines within the investigation area, which also was pointed out by Ringberg (1971). The areas below the highest shore line between the river valleys are characterized by thin till deposits following the topography, while those areas above the highest shore line are characterized by a hummocky dead-ice landscape. This probably means that in the areas situated below the highest shore line the thickest ice was found in the deepest parts of the terrain, that is in the river valleys and present-day lake basins. However, it has already been shown that the southern parts of river valleys as well as the basins (e.g. Logylet and Kroksjön) became ice-free during an early phase of the deglaciation. The result of the suggested transgression would thus be calving of dead-ice in large parts of Blekinge and probably also a transgression over already partially ice-free areas, preferentially in areas between the river valleys below the highest shore line. The river valleys between 50 and 70 m a.s.l. are mainly characterized by the Svängsta Formation, consisting of till, sharp-edged eskers, kame deltas and kame terraces. The eskers are usually situated in the middle of the river valleys, reaching 10 - 15 m above the bottom of the valleys. Kame deltas are mainly found in the wider parts of the valleys with the top surfaces usually situated between 60 and 70 m a.s.l. The kame terraces are located on the valley slopes at altitudes of more than 55 m a.s.l. These three different types of glacio-fluvial deposits represent a gradual wasting of ice in the river valleys between 50 and 70 m a.s.l. The eskers were mainly formed during the early phase of this ice-wasting as the first ice-disintegration features. As the ice was gradually separated into blocks, kame deltas were formed in the larger cavities between these blocks. Some of these deltas seem to

have been delimited by relatively big ice-blocks. The uppermost strata at e.g. sites 1c and 2b shows that some of these deposits could have been influenced by regional water level during their last phase of deposition. The kame terraces represent the last deglaciation phase in the river valleys. They were formed supraglacially or between the thin ice and the usually steep valley slopes. At higher altitudes in the valleys it is possible to find more than one terrace at the same place (e.g. site 1a), which thus represents the gradual wasting of ice. This means that the postulated transgression could have caused calving of at least some parts of the thin ice in the valleys below the highest shore line, while the ice-disintegration features at or above the highest shore line represent a more complete ablation sequence. If the Baltic Ice Lake influenced some of the kame deltas it would mean that the water level was situated at or below 65 m a.s.l. As has been pointed out before, large parts of the Danstorp Member are correlated with the diffuse varve type. These varves were deposited about 200 - 250 varve years after the deglaciation of the present coast-line. The main reason that this member was originally deposited around today's 55 m contour line is believed to be that the valleys were not free from ice above this altitude. As these first deposits consist mainly of bottomset beds, it is hard to relate them to water level. However, as the lowermost parts of these bottomset beds are situated below 45 m a.s.l. the water level must at least have been situated higher than 45 m a.s.l. when they started forming, and when the upper parts of these bottomset beds were deposited, the Baltic Ice Lake level must have had an altitude of at least 50 m. It is possible that parts of the Danstorp delta (Lagerlund and Björck 1979), the Tararp delta (site 1d), the Muggeboda delta (site 2c) and the Bredåkra delta (site 3b) were completely formed before the regression started, thus being a pure glaciogenic deposit as almost the whole Sörby Varved Clay Member predates the regression. In this case the topset beds indicate a water level of about 55 m a.s.l. before the highest shore line was reached and thus demonstrating a transgression from at least 55 m a.s.l. up to the highest shore line. However, as no fine-grained sediments have yet been found on top of the topset beds, the deltas are for the moment interpreted as having been completely formed during the regression, thus being a mixture of glaciogenic as well as pure fluvial origin. An important and interesting question in connection with the 55 m deltas is the source of the usually dominant bottom-

set beds, especially as they are interpreted as being deposited more or less synchronously. The river valleys where the bottomset beds are most dominant, drain not just parts of Blekinge, but also large parts of southern Småland. It is thus probable that changes in the drainage pattern in the northern parts of the drainage areas are recorded at the river mouths in Blekinge. One explanation for this change in drainage pattern, which appears to have been almost synchronous within Blekinge, could be tapping of ice lakes in southern Småland. The reason for such tapping could be that it took place as a natural event in a deglaciation course of a wasting ice. However, this tapping could also be explained by a sudden climatic amelioration during the late Bölling Chronozone. Whatever this drastic change in sedimentation was caused by, the sediments were probably transported above the ice situated in the northern parts of the valleys and finally deposited where the ice had calved. It is difficult to say exactly when the river valleys became free from ice, but without doubt the end of the varved clay gives a minimum age for a mainly ice-free Blekinge. However, most of the ice in Blekinge had probably melted earlier, as the river valleys also drain very large parts of southern Småland. This would suggest instead that the last varves in Blekinge could be correlated with the last phase of the deglaciation in southernmost Småland. However, too little is known about the processes forming varved clay to be able to know what the presence or absence of this sediment really means. Although Kroksjön is not located in a large river valley, the youngest clay varves in Blekinge were found in this basin. In any case, Blekinge was certainly almost completely free from ice at about 12,000 radiocarbon years B.P. It is, however, unquestionable that dead-ice could remain in particular situations even after that date. This is shown by pronounced kettle-holes and extensive settings in sediments belonging to or in contact with the Danstorp Member e.g. at Asarum (Lagerlund and Björck 1979), Tararp (Sandgren and Åmark 1975) and Muggeboda (site 2c) as well as by the presence of regressive deltas in the Mörrumså river valley situated at higher altitudes than ice-disintegration features north of these deltas (Lagerlund and Björck 1979). The reason why dead-ice remained in these areas was probably due to the fact that the ice was at least partly buried beneath sediments, which prevented the ice from calving as well as melting quickly. When the ice finally melted, the sediments collapsed and kettle-holes and settings were formed. This was the last glaciogenic influence on the sediments

in Blekinge, which means that the Lower Listerby Formation, the Svängsta Formation and large parts of the Mörrum Formation were directly influenced by deglaciation processes during the deglaciation of Blekinge.

The deglaciation pattern described above can be summarized as follows.

- 1/ The southern part of Blekinge became ice-free by calving from an ice-margin.
- 2/ Between 35 and 55 m a.s.l. the river valleys were deglaciated by calving of dead-ice.
- 3/ From 55 m a.s.l. up to about the highest shore line the deglaciation was characterized by ablation, but the last deglaciation phase could at least partially have been characterized by calving of very thin ice.
- 4/ Areas above the highest shore line were deglaciated by ablation.
- 5/ The later phase of the deglaciation was characterized by a sudden increase in discharge of silty sediments, forming bottom-set beds in deltas with their topset beds today situated at about 55 m a.s.l.
- 6/ Blekinge was deglaciated before 12,000 conventional radiocarbon years B.P., which means that Blekinge was deglaciated during the later part of the Bölling Chronozone.
- 7/ The last traces of the inland-ice in Blekinge are collapses caused by dead-ice buried beneath sediments and some ice-disintegration features in e.g. the Mörrumså river valley. According to the shore line displacement curve this could have happened some time during the Alleröd Chronozone.

12. LATE WEICHSELIAN GEOLOGICAL EVENTS WITHIN AND AROUND THE BALTIC BASIN - A REGIONAL SYNTHESIS

This investigation has dealt with a very restricted time period in the geological development in Blekinge. It has, broadly speaking, been delimited by the deglaciation of the coast of Blekinge and by the sudden lowering of the Baltic Ice Lake level at the end of the Younger Dryas Chronozone, which means that the length of this period is between 2,000 and 2,500 radiocarbon years. To be able to understand many of the events recorded in this investigation it is often necessary to relate them to known or suggested events from other areas. It is also possible to give explanations on the basis of the development recorded in Blekinge for courses of events that have been difficult to interpret in other areas. One of the main advantages when correlating events in Blekinge with events in other areas is that the development in Blekinge has to a large extent been influenced by water level changes of the Baltic Ice Lake, which, due to its size, influenced and also was influenced by the development in areas distant from Blekinge. The events recorded in Blekinge which are assumed to be relatable with events outside the investigation area will be described and discussed in chronological order. These events are related to the shore line displacement curve in Fig. 82.

1/ As a transgression of the Baltic Ice Lake has been suggested during the earliest development described within the investigation area, it is necessary to explain how this transgression could take place. It is believed to be a result of damming of the Baltic Ice Lake. Such damming must have been due to some type of rising of the threshold, which was most likely situated somewhere west of Scania. If this rise was due to isostatic uplift at the threshold it would mean that the isostasy at the threshold was larger than the isostasy in Blekinge, as transgression took place in Blekinge, which literally means that the isostatic effect in Blekinge "drowned" in the eustatic effect caused by the isostasy at the threshold. However, this was hardly the case as the values of today's isobases are lower in the postulated threshold area than in Blekinge. It is also obvious that the isostatic effect in Blekinge during the time of transgression should have reached its maximum value as the deglaciation was followed by the transgression. Lagerlund (1977a and 1977b), however, pointed out the possibility of neotectonic

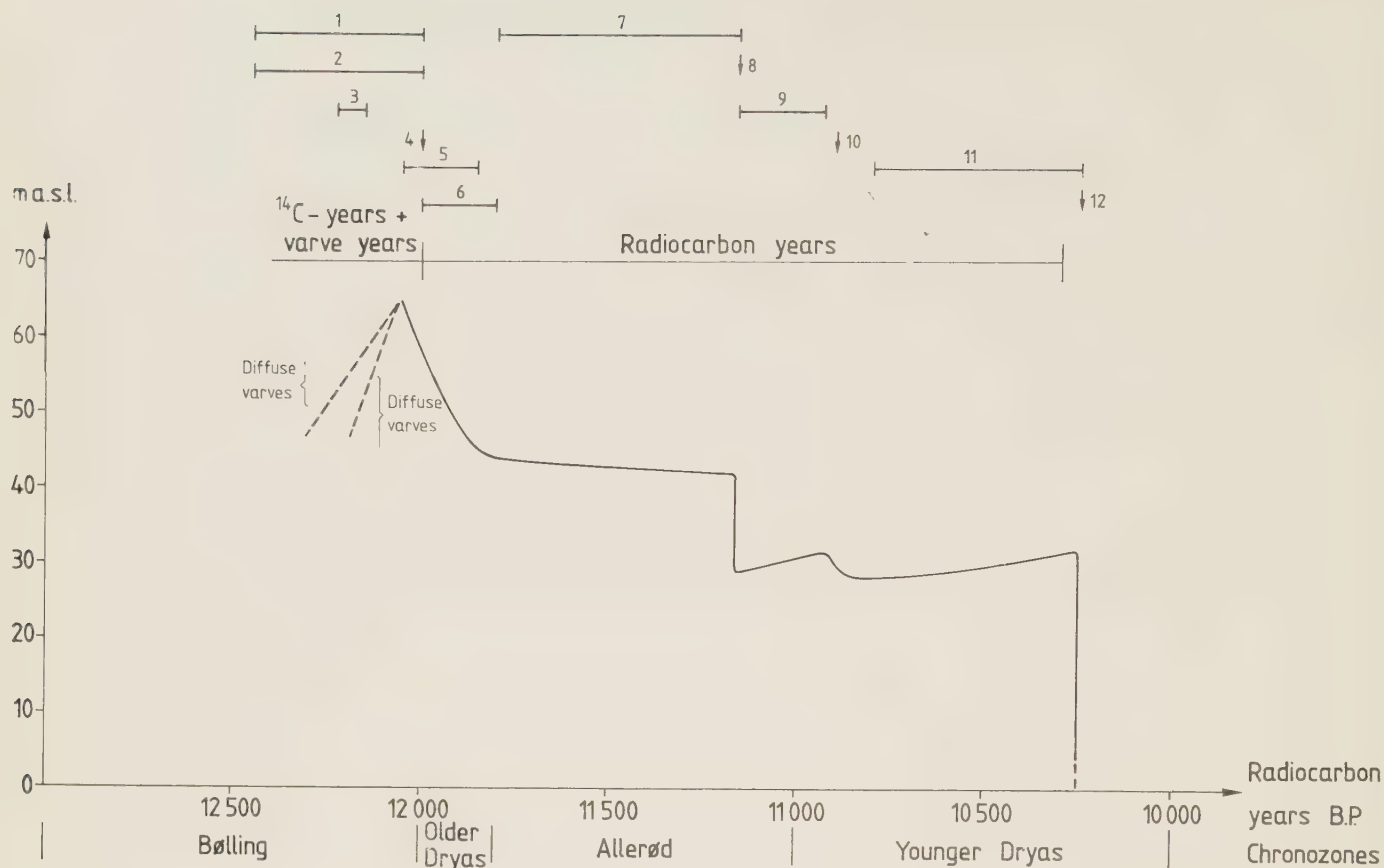


Fig. 82. The twelve geological events discussed in Chapter 12 related to the Late Weichselian shore line displacement curve in Blekinge.

movements in northwest Scania during the Late Weichselian. Those investigations combined with the confusion about the altitude of the highest shore line in the probable threshold area shows the possibility of explaining rapid damming of the Baltic Ice Lake by sudden movements at the threshold area. Another explanation for this transgression could have been damming by ice at the threshold, or south of Blekinge, forming a local ice-lake. Stay (1979), however, showed that the Bornholm basin was deglaciated before the deglaciation of Blekinge started, which means that the Hanö bay could not have been an isolated dammed ice-lake during the transgression. It also shows that the southwestern part of the Baltic basin was most likely free from active ice when the transgression in Blekinge took place. Nilsson (1968), however, thought that the threshold of the Baltic Ice Lake was blocked by dead-ice, causing damming. There are, thus, different possible explanations for a transgression in Blekinge during the deglaciation.

2/ The deglaciation pattern described shows that the inland-ice was probably very thin during the deglaciation in Blekinge and that the deglaciation model suggested and described by Berglund (1976 and 1979) and Bjelm (1976) is also valid for Blekinge. The first indications of such a deglaciation type in Blekinge was shown by Ringberg (1971). This new deglaciation model in Blekinge is summarized from a lithostratigraphical point of view by Lagerlund and Björck (1979).

3/ The sudden change in sedimentation during the deposition of the diffuse varve type and formation of large bottomset beds in Blekinge is assumed to be related to drainage changes in ice-lake complexes in southern Småland. E.g. Rydström (1971) showed that these parts of Småland were characterized by ice-lakes of varying size. As these areas are nowadays drained by the rivers and streams of Blekinge, the conditions should have been approximately the same during the deglaciation. When these ice-lakes were drained it most likely influenced the stream velocity as well as the amount of transported material in the rivers and streams of Blekinge. As this seems to have taken place during a relatively short and synchronous time period it is possible to correlate these sudden changes in sedimentation rate with a climatic amelioration during the later part of the Bölling Chronozone, causing a relatively rapid melting of ice. This sudden increase in sedimentation could, however, also reflect the final phase of a gradual wasting of ice, the remaining ice at certain points being unable to dam up the quantities of water in question.

4/ As the rivers and streams of Blekinge drain an area 2.5 times the size of Blekinge (the whole of Blekinge and 1/7 of Småland) traces of the deglaciation of at least southern Småland can probably be expected in Blekinge. This means that it should be possible to correlate the end of the varved clay in Blekinge with the final deglaciation phase in southernmost Småland. This would mean that Blekinge and southern Småland, with the exception of some localities with dead-ice, were ice-free at about 12,000 radiocarbon years B.P.

5/ It is clear from Fig. 82 that the shore line displacement was characterized by a rapid regression during the Older Dryas Chronozone. The rate of this regression was at least 10 m/100 years. There

are at least three facts showing that this could not have been due to the isostatic effect in Blekinge during this time.

a/ The maximum value of post-glacial uplift in Arctic Canada was 10 m/100 years according to Andrews (1970). One must, however, bear in mind that this area was situated near to the centre of the Laurentide ice sheet.

b/ If no erosion of the threshold took place during the regression in Blekinge the isostatic effect in Blekinge would have been the rate of regression in Blekinge + the isostatic effect at the threshold, thus considerably greater than the recorded regression. This value would be much higher than 10 m/100 years, which must be regarded as impossible, provided that Blekinge was not subjected to a tectonically dependent uplift.

c/ Andrews (1968) has shown that over a 10,000 year interval, 20 per cent of the postglacial uplift takes place during the first 500 years following deglaciation. In Blekinge the uplift is more than 20 m (see b/) during about 200 years which should be at least 20 per cent of the total uplift, as the eustatic rise since deglaciation is about 30 m and the highest marine influenced shore-line is at least not higher than 65 m a.s.l.

There are thus many facts which show that the regression after the development of the highest shore line does not reflect the isostatic effect. The dates of the isolation levels in the highest situated basins, as well as the shore line displacement curve show that, although the gradient is high, the regression was gradual, which would probably not have been the case if this rapid regression was due to disappearance of dead-ice blocking at the threshold. The most probable explanation for these 200 years of the shore line displacement curve is believed to be erosion of the threshold. When the Baltic Ice Lake reached the threshold the highest shore line was developed in Blekinge, and possibly also in all ice-free areas around this large ice-lake, perhaps with the exception of the northernmost ice-free areas. As the water started to pass the threshold area, erosion began. If the rate of erosion at the threshold, during these 200 years, was e.g. 10 m larger than the isostatic effect, the isostatic gradient in Blekinge would have been about 5 m/100 years during this time period. The end of the rapid regression could be related to the time when the erosion reached the bed-rock at the threshold.

6/ The climatic deterioration during the Older Dryas Chronozone (the Regional Assemblage Zone 2), recorded biostratigraphically, is not that clearly recorded in the lithostratigraphy of Blekinge. This possibly means that the inland-ice was too distant during this stadial to influence at least the lacustrine sedimentation in Blekinge. However, some larger delta surfaces were most likely formed during this chronozone, as well as minor delta surfaces in the Alleröd Chronozone.

7/ Slightly before the boundary between the Older Dryas Chronozone and the Alleröd Chronozone the regression gradient changes from about 10 m/100 years to 0.4 m/100 years. If this change is related to the end of the erosion at the threshold this gradient is the same as the difference between the isostasy in Blekinge and the isostasy at the threshold. This means that it should be possible to determine the altitude of the threshold during that time period, which also means that the highest altitude of the threshold is possible to determine if the rate of erosion of the threshold could be determined. However, as calculations like this must be based partly on speculation regarding isostatic gradients at different localities, the reliability of the isobase system, rate of erosion etc, the possibility of using this interpreted gradient difference for different calculations is just pointed out. In any case, this would mean that the water level in areas situated at or very near the threshold was stable, while areas south and southeast of the threshold were transgressed and areas near to the ice-margin were influenced by a probably marked regression. It should be pointed out that this difference in isostasy between Blekinge and the threshold area could explain the very low regression gradient at Sännen and Logylet if the deglaciation of these lakes was synchronous with the highest shore line. However, then it would be much harder to explain the following rapid regression during the Older Dryas Chronozone.

8/ The end of the Alleröd Chronozone is characterized by a very sudden lowering of the water level in the Baltic Ice Lake (Fig. 82). This event is interpreted as tapping of the ice-lake, probably caused by deglaciation north of the hill Billingen. The new deglaciation chronology presented by Berglund (1976 and 1979) makes this interpretation possible. As this tapping seems to have occurred 100-200 years before the end of the Alleröd Chronozone, the ice-

recession should have continued some distance north of Billingen before the climatic deterioration during the Younger Dryas Chronozone started. This assumption is supported by investigations carried out in southeastern Norway (Sörensen 1979) and in the area west of Lake Vänern (Johansson 1978). The level of tapping seems to have been about 15 m. Donner (1969) thought that the g-level in Finland represents the sea level, but there is nothing, either in the biostratigraphy or in the lithostratigraphy in Blekinge that indicates a contact with the sea during the very late part of the Alleröd Chronozone. The diatom flora from this time in Halsjön II (site 10b) does not suggest any salt water influence. It should, however, be pointed out that the investigation area was situated very far away from the eventual straight between the sea and the Baltic Ice Lake. This straight was probably also characterized by melt water flowing from the Baltic Ice Lake into the sea preventing salt water from coming into the Baltic basin to such a degree that the ice-lake environment changed. It will be shown later on that from an isostatic and eustatic point of view it is possible that this tapping could have caused contact with the sea.

9/ The later part of the Alleröd Chronozone and the very beginning of the Younger Dryas Chronozone is characterized by a transgression with a gradient of about 1 m/100 years. This transgression in Blekinge could be explained by the fact that the isostatic effect at the threshold at Billingen (situated 250–300 km NNW of Blekinge) during this time period was at least 1 m/100 years larger than the isostatic effect in Blekinge, causing an eustatic rise of the ice-lake level 1 m/100 years larger than the isostasy in Blekinge. This is most possible as the ice had just left the area producing an increasing isostatic effect as a consequence.

10/ According to the shore line displacement curve (Fig. 82) the above mentioned transgression lasted for about 100 years during the Younger Dryas Chronozone. This means that the ice-recession would have stopped and probably been replaced by a readvance of the ice. Whether this suggested readvance had anything to do with the lowering of the Baltic Ice Lake at about 10,900 cannot be determined for certain. There are, however, two possible explanations for this regression. The first one is based on the presumption that the drainage at the threshold area changed so that some

Ice-marginal zone	Radiocarbon age B P		Chronostratigraphy		
	Traditional	Revised	E. Nilsson 1968	Mörner 1969, 1971	Mangerud et al 1974
7. Billingen Moraine	10,000 - 10,200	10,200 - 10,400	Younger		Younger
6. Skövde Moraine	10,400 - 10,700	10,600 - 10,900	Dryas	Younger	Dryas
5. Levene Moraine	c. 11,000	11,800 - 12,000	Alleröd	Dryas	Alleröd
4. Trollhättan Moraine	c. 11,400	c. 12,200			Older Dryas
3. Berghem Moraine	11,800 - 11,900	c. 12,400		Alleröd	Bölling
2. Göteborg Moraine	12,000 - 12,300	12,600 - 12,800		Older Dryas	
1. Halland Coastal Moraine and Low Baltic Readvance	12,800 - 13,000 c. 13,000	13,000 - 13,500 13,000 - 13,200	Bölling	Fjärås	
			Oldest Dryas	Ågård	

Fig. 83. Deglaciation chronology in SW Sweden according to the traditional and the revised (Berglund 1976 and 1979) view.

erosion of the new threshold could take place causing a relatively rapid lowering of the water level. The second possible explanation is based on the assumption that the ice readvanced, which probably caused a considerable slowing down of the isostasy at Billingen. This means that the isostatic effect in Blekinge was larger than the eustatic effect caused by a slowing down of the isostasy at the threshold. If the second explanation is correct this regression probably just predates the readvancing ice at Billingen. As the Skövde Moraine is dated to 10,900 - 10,600 B.P. by Berglund (1979) this would indicate that the readvance was rapid.

11/ The majority of the Younger Dryas Chronozone is interpreted as being characterized by a slow transgression (Fig. 82). According to all authors who have dealt with the Middle Swedish end-moraines, the Skövde and Billingen Moraines (Berglund 1976 and 1979) were formed during the Younger Dryas Chronozone (Figs. 83 and 84). If the inland-ice was situated north of Billingen at the boundary between the Alleröd and the Younger Dryas Chronozone it must thus have readvanced during the Younger Dryas Chronozone, which could also be supported by the regression at about 10,900 B.P. As the ice readvanced over the former drainage passage of the Baltic Ice

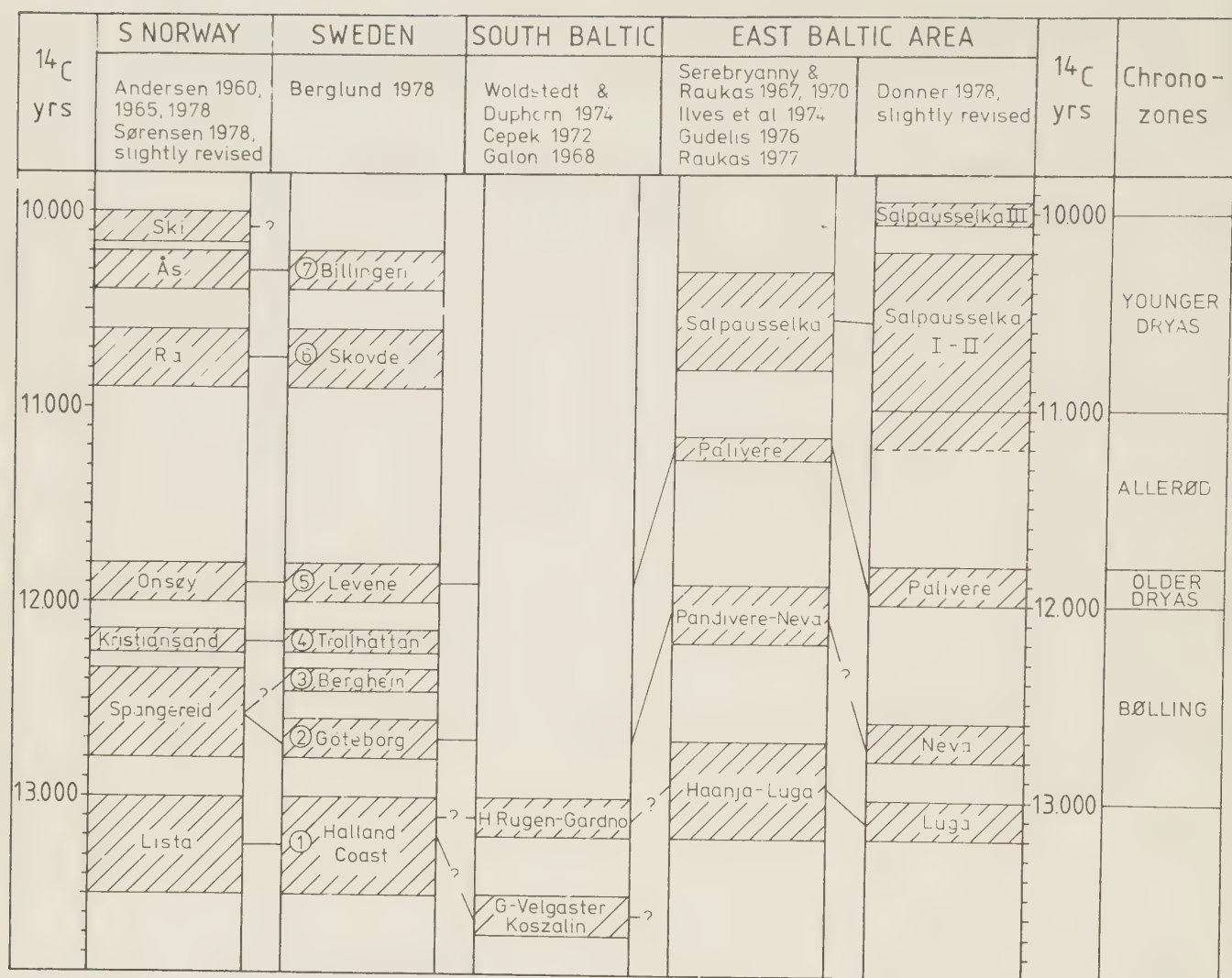


Fig. 84. Ice-marginal zones chronologically correlated with the moraine sequence of SW Sweden. From Berglund (1979).

Lake, the regression would have been replaced by a transgression if the advancing ice was dense enough to dam up large quantities of water. With such an interpretation of a slow transgression (about 0.7 m/100 years) it would mean that the eustatic rise, caused by damming of the threshold by active ice, was larger than the isostatic effect in Blekinge. Donner (1978) dated the beginning of the Younger Dryas transgression to 8,900 varve years B.C., which is in surprisingly good agreement with my date (about 10,900 radiocarbon years B.P.). However, this is probably more a coincidence than a true relationship. It is also worth emphasizing that neither the transgression nor the regression preceding the last transgression are found in Finland, which is to be expected as these events were only a function of the relation between the isostasy in Blekinge and at the threshold area. Donner (1969)

has estimated the height of the transgression to 25 m (Fig. 50), while it is estimated to have been about 5 m in Blekinge. The only possible explanation for this difference must be due to differences in the isostatic effect between the two areas. This means that the Salpausselkä area would have been characterized by down-warping as uplifting in Blekinge was probably less than 20 m during these 600 years. The amount of Gudelis' (1961) transgression during Younger Dryas is, however, hard to explain without taking sudden tectonic movement into account. Donner (1978) has also shown that the ice was active during the Younger Dryas Chronozone. However, the velocity of the transgression is according to Donner (1969) much higher than is recorded in Blekinge. Saarnisto (in prep.) has shown that it is possible to interpret some of the deposits in the Salpausselkä area in a way that is in closer accordance with the slow transgression in Blekinge. How far this readvance reached is of course not possible to say on the basis of the information obtained for this investigation, but according to Berglund (1976 and 1979) it did not advance south of the Skövde Moraine. The youngest date of this Moraine is 10,600 B.P. (Berglund 1979), which corresponds relatively well with the climax of the climatic deterioration during the Younger Dryas Chronozone in Blekinge (10,500 B.P.). This interpretation of the pattern at the Middle Swedish end-moraines, based mainly on water level changes in the Baltic Ice Lake, shows that sediments deposited during the ice-recession in the Alleröd Chronozone could be buried beneath deposits formed during the readvance in the Younger Dryas Chronozone. It does also imply that deposits formed during the late Alleröd Chronozone could be missing due to erosion at the readvance. This clearly shows the difficulties connected with prolonging "The Swedish Time Scale", based on varve chronology, south of the Middle Swedish end-moraines.

12/ The last phase recorded in the Late Weichselian shore displacement from Blekinge is a sudden lowering of the Baltic Ice Lake. Whether this occurred gradually or not is difficult to determine with certainty, as the datings of the isolations recorded contain certain margins of error. However, the Baltic Ice Lake was lowered from 30 m a.s.l. down to at least 4 m a.s.l. between 10,300 - 10,200 B.P., which gives this lowering an age of 10,250 radiocarbon years B.P. This corresponds well with the date of the final tapping given by Berglund (1966). This rapid lowering of the Baltic Ice

Lake is thus interpreted as being related to the final tapping of this ice-lake at Billingen. In Finland (Niemelä 1971) as well as in Sweden (Nilsson 1968) this tapping has previously been dated to 8,213 varve years B.C., which is based on the revised "Swedish Time Scale" (Nilsson 1968). Berglund (1976 and 1979) thinks that the Billingen Moraine was formed between 10,400 and 10,200 radiocarbon years B.P., which fits well with my date. Donner (1969 and 1978) related the tapping of the Baltic Ice Lake to the lowering of the water level from the BIII level down to the YI level, which occurred some time between the formation of Salpausselkä II and III. These two zones have been dated by pollen analysis as well as by radiocarbon analysis (Donner 1978). These dates show that the tapping took place some time between 10,200 and 10,000 radiocarbon years B.P. Donner (1978) suggested the possibility that the tapping could have been gradual in part, which is supported by investigations made by Perhans (1979) in Östergötland, but there is, however, no evidence from Blekinge to show such a development. The date from Blekinge (10,250 B.P.) shows that ice-recession must have taken place after the Skövde Moraine (Berglund 1976 and 1979) was formed, which means that the deglaciation from the Skövde Moraine to the Billingen Moraine took place over about 300 years. The climatic deterioration in Blekinge reached its maximum at about 10,500 B.P., which seems to have been followed by a 300 years period of slightly better climate (zone 6), during which the ice-recession from the Skövde Moraine to the Billingen Moraine must have taken place if Berglund's dates of these zones are correct. According to the shore line displacement in Blekinge the final tapping took place before zone 7. This zone represents the first sign in Blekinge of the climatic amelioration characterizing the Holocene. This means that the ice was either north of Billingen or that the ice was not dense enough to dam the Baltic Ice Lake at the end of zone 6. In any case, this possibly indicates that the active inland-ice was situated north of Billingen before the drastic climatic change was recorded in the lakes of Blekinge. However, it should be noted that the pollen spectra do not change immediately at a climatic amelioration due to a delay in the response of the vegetation. The depth of the tapping is at least 26 m in Blekinge. Donner (1969 and 1978) thought that the YI level was reached after a lowering of the Baltic Ice Lake of about 28 m, which coincides well with the values determined from Billingen. In connection with this tapping, which is supposed to have reached the sea level, it

is appropriate to discuss whether the suggested tapping at the end of the Alleröd Chronozone reached the sea level or not. Assuming it did, it means that the sea level in Blekinge was situated slightly lower than 30 m a.s.l. at that time. As the eustatic rise of the sea level during the Younger Dryas Chronozone is estimated to have been about 10 m (see Andrews 1970) and if the final tapping was about 30 m this shows that the eustatic rise in the Baltic Ice Lake + the isostatic uplift at the threshold was about 40 m for at least 600 years. The isostatic rise in the threshold area was probably considerable after the ice left the Skövde Moraine, and the eustatic rise during these 600 years was probably also large. If the isostasy in Blekinge during the Younger Dryas Chronozone had a moderate mean gradient, between 1.5 and 2.5 m/100 years, it would mean that the eustatic rise was about 20 m, which would require an isostatic uplift at the threshold of about 20 m. As none of these figures are improbable it could mean that the Baltic Ice Lake was in contact with the sea during the late Alleröd Chronozone. It must, however, be pointed out that the amount of the final tapping in Blekinge is just a minimum value and that the answer of the true value probably lies beneath today's sea level. This last large lowering of the Baltic Ice Lake must have caused erosion in the river valleys around the coast of this huge ice-lake. The lower reaches of these rivers were thus probably finally shaped due to the climatic amelioration that turned the Baltic Ice Lake into the Yoldia Sea, which also represents the transition from the Pleistocene to the Holocene in the Baltic basin.

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